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PROPAGATION TRIALS ON BANANA

I.—EFFECT OF SIZE OF SUCKERS AND HEADING BACK ON GROWTH, MATURITY, YIELD, AND GRADE OF FRUIT

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(With 1 Text-Figure)

BANANA is propagated mostly from suckers in West Bengal. Tall suckers well over 5 feet in height are preferred to smaller ones as the latter are more prone to damage from stray cattle. Transport of big suckers is difficult and expensive, and is a great problem specially in rural areas during the rainy season where all-weather roads do not exist. Pruning of suckers before planting, particularly the large ones, would reduce the cost in transport considerably.

When suckers are planted a few days after lifting, leaf sheaths at the apex usually dry up and do not permit new lamina to emerge, restricting growth and sometimes eventually leading to complete rotting of the heart bud. The shrivelled or decayed portions of the pseudostem have to be cut back in such cases to facilitate growth. The present investigations were undertaken to find out the optimum size of suckers and the effect of heading them back before planting on growth, maturity, yield, and grade of fruit.

Stephens [1945] is of the opinion that suckers not more than 2 feet high for dwarf types and 5 feet high for tall varieties should be used for planting. There was no difference in the yield between tall suckers over 2 feet 6 inches high, and short suckers 2 feet to 2 feet 3 inches high, in an experiment conducted on the Lacatan variety by the Department of Agriculture, Jamaica [1950-51]. In another experiment on the same variety, the height at shooting and yield of maiden suckers, ' half head ", " quarter head ", and peepers were found to vary a little only. Gandhi [1952] considers suckers larger than 5 feet in tall varieties and 3 feet in dwarf varieties unsuitable for propagation. Borel [1952] obtained better results from whole suckers than cut back suckers in an experiment conducted in the French Cameroons. Cheema and others [1954] described the practice of heading back of suckers to two-thirds of their original length before planting followed in the Bombay State. Oppenheimer and Gottreich [1954] reported the superiority of large-sized suckers to medium-sized, and medium to small-sized as regards flowering time, size of bunch, and subsequent sucker production in an experiment conducted on the dwarf banana in the coastal plain of Israel.

Sword suckers treated before sowing

Materials and Method

The experiment was conducted in a well-drained alluvial loamy soil at Krishnagar in West Bengal. *Champa*, a commercial variety of the State, was selected for the experiment. Sword suckers from healthy stools were selected and given the following treatments before planting.

Treatments

A. 3-foot high suckers with leaves pruned only ;

B. 3-foot high suckers headed back one foot from top ;

C. 3-foot high suckers headed back 2 feet from top ;

D. 4-foot high suckers with leaves pruned only ;

E. 4-foot high suckers headed back one foot from top ;

F. 4-foot high suckers headed back 2 feet from top ;

G. 5-foot high suckers with leaves pruned only ;

H. 5-foot high suckers headed back one foot from top ; and

I. 5-foot high suckers headed back 2 feet from top.

The layout followed was randomised blocks with 4 replications. There were 9 plants in each sub-plot, spaced 9 feet 6 inches by 9 feet 6 inches. The experiment was planted on the 16th July, 1951. Manuring, cultural and desuckering practices were attended to in the usual manner. Observations were commenced two months after planting and continued bi-monthly till shooting. Height and girth were measured to the nearest inch.

The treatment G gave the greatest height measurement of all in September, 1951. The difference in height between G and D, and A and D became nonsignificant in November, 1951, and January, 1952, respectively ; the superiority of G over A, however, persisted till March, 1952. The trend in girth was more or less similar to that in height. The treatment G recorded greater girth than A till November, 1951, only ; whereas the difference in girth between A and D became nonsignificant in the November observations.

Heading back of suckers caused only a temporary check in growth. In the 3-foot group, treatments A and B recorded greater height than C in November, 1951, and January, 1952 ; however, the difference in girth between A and C was observed only in January, 1952. There was no significant difference in height and girth between A and B throughout the period of growth. Heading back did not produce significant effect on growth of the 4-foot suckers. In the case of 5-foot suckers, however, treatment G recorded greater height and girth than H and I in September, 1951 only, the difference thereafter becoming nonsignificant.

The effect of season on growth is well marked. Growth in almost all the treatments was slowest during the winter months, i.e., from November, 1951 to January, 1952, followed by the period from January to March, 1952 ; while with the receipt of about 5 inches of rainfall in March and April, 1952, and warm weather, the growth was very rapid till shooting.

Results

(*a*) *Growth*

The effect of size of suckers on growth was temporary. The height and girth measurements are summarised in Tables I and II.

(*b*) *Maturity*

Inspection of the data presented in Table III shows that height and heading back of suckers had a marked influence on maturity, that is, the period from planting till harvest.

The period of maturity in G was the shortest of all the treatments ; there was, however, no significant difference between A and D. Heading back of the 5-foot suckers in treatments H and I significantly delayed maturity as compared with G, and reduced to nonsignificance the difference between H and I on the one hand, and the 3-foot and 4-foot suckers, headed back or otherwise, on the other hand. There was, however, no significant effect on maturity by heading back the 3-foot and 4-foot suckers. It is rather noteworthy that heading back of the 3-foot suckers in treatment C increased the period of maturity to a significant level as compared with the treatments D and E, viz., 4-foot suckers with leaves pruned only and cut back one foot from top respectively.

(*c*) *Yield*

Harvesting of the plants commenced in September, 1952, and the entire plant crop was over by January, 1953. The yield data are summarised in Table IV.

Size of suckers as well as heading back did not produce significant effects on yield.

(*d*) *Hands and fingers*

Inspection of the data in Table V reveals that size of suckers and their heading back did not affect grade of the fruit, i.e., the number of hands per bunch.

In the case of fingers per bunch, treatment I recorded the highest number of all, followed closely by G, D, B and H ; whereas F produced the smallest number except C and A.

Discussion

The superiority in growth of the 5-foot suckers with leaves pruned only (G), which is the usual local method of planting, over 3-foot (A) and 4-foot (D) suckers was temporary and persisted till March, 1952, and November, 1951, respectively. There was no significant effect of heading back the 4-foot suckers on growth ; whereas in the 5-foot suckers, difference was noticed only in the initial stage. However, growth of the 3-foot suckers cut back 2 feet from top (C) was most retarded of all the treatments. The effect of heading back of suckers on growth, likewise the size of suckers, was temporary.

Height and heading back of suckers exerted marked influence on maturity. The 5-foot suckers with leaves pruned only (G) matured on an average about three and a half weeks earlier than 4-foot suckers (D) and about seven weeks earlier than

TABLE I

Height (inches)

Period	Treatments									S. E. of mean difference	Critical difference P=0·05	Remarks
	A	B	C	D	E	F	G	H	I			
1951												
September	13·97	14·75	13·07	12·75	13·02	15·72	19·55	15·70	14·05	1·78	3·66	G F H B I A C E D
November	29·85	27·87	25·05	32·77	31·50	33·07	36·12	32·35	32·82	2·27	4·67	G F I D H E A B C
1952												
January	34·55	32·15	28·50	39·75	35·65	36·85	41·40	37·70	38·40	2·71	5·58	G D I H F E A B C
March	41·20	40·90	37·60	47·80	43·45	45·05	50·00	46·80	48·10	3·48	7·16	G I D H F E A B C
May	83·05	84·20	84·80	86·10	83·60	82·05	83·75	83·70	88·10	..	..	Nonsignificant

TABLE II

Girth (inches)

Period	Treatments									S. E. of mean difference	Critical difference P=0·05	Remarks
	A	B	C	D	E	F	G	H	I			
1951												
September	6·15	5·82	5·67	6·25	5·95	6·27	7·02	6·22	6·17	0·33	0·67	G F D H I A E B C
November	8·45	8·00	7·55	9·25	8·67	8·85	9·95	8·92	9·52	0·59	1·21	G I D H F E A B C
1952												
January	10·55	9·52	8·77	11·65	10·85	10·60	11·95	10·80	11·15	0·86	1·77	G D I E H F A B C
March	10·95	10·57	9·60	12·70	11·25	11·85	12·75	11·95	12·40	..	..	Nonsignificant
May	19·20	19·40	19·30	19·30	20·10	19·00	18·75	19·75	21·40	..	..	Nonsignificant

TABLE III

Maturity (number of days from planting till harvest)

Mean	Treatments									S. E. of mean difference	Critical difference P=0·05	Remarks
	A	B	C	D	E	F	G	H	I			
Life in days	480·25	486·75	494·50	469·75	464·25	475·50	430·50	474·25	477·50	11·94	24·59	C B A I F H D E G

TABLE IV

Yield per plant (pounds)

Mean	Treatments									S. E. of mean difference	Critical difference P=0·05	Remarks
	A	B	C	D	E	F	G	H	I			
Yield	20·12	19·95	19·82	21·30	21·00	19·67	19·82	20·95	22·80	..	..	Nonsignificant

TABLE V

Hands and fingers per bunch

Mean	Treatments									S. E. of mean difference	Critical difference P=0·05	Remarks
	A	B	C	D	E	F	G	H	I			
Hands	7·17	7·85	7·57	7·72	8·00	6·60	6·95	7·77	8·75	..	..	Nonsignificant
Fingers	86·65	100·60	87·02	100·65	99·75	79·27	101·70	100·17	114·02	6·32	13·01	I G D B H E C A F

3-foot suckers (A). There was no significant difference in maturity between 3-foot and 4-foot suckers. Heading back of suckers did not affect maturity in the 3-foot and 4-foot suckers, whereas it considerably increased the period of maturity in the case of 5-foot suckers. It thus appears that check in growth due to heading back was more marked in the 5-foot suckers and appreciably delayed the reproduction phase than in younger suckers, or, in other words, the younger suckers take much less time to recoup from the check in growth due to heading back than old suckers. This phenomenon has an important practical bearing. The damage to suckers after planting due to stray cattle, storm or any other agency which would necessitate their heading back to permit emergence of new leaves at the growing point, would adversely affect maturity of the grown up suckers to a greater extent than that of the younger suckers.

The yield and number of hands per bunch were unaffected by the size and heading back of suckers. The number of fingers per bunch, however, presents a different picture. The five-foot suckers headed back 2 feet from top (I) produced the largest number of fingers, whereas the 4-foot suckers headed back 2 feet from top (F) were the most adversely affected of all the treatments. When only leaves were pruned, the 3-foot suckers (A) produced smaller number of fingers than 4-foot (D) and 5-foot (G) suckers, though at a very small margin of significance. The peculiar behaviour of fingers needs further study.

Banana is a long duration crop, taking nearly 10 months to flower under favourable conditions in *Champa* variety, and it may be expected that temporary check in growth caused by heading back or the initial disadvantage due to size of suckers at the time of planting should have been ultimately overcome without adversely affecting the yield. It may be inferred from the grower's point of view that 3-foot, 4-foot and 5-foot high suckers are equally good for planting, the only difference being that the 5-foot suckers mature earlier than the former. Where transport is a problem, smaller suckers should be preferred. Heading back of 5-foot tall suckers for convenience in handling has the definite disadvantage in delayed maturity.

Summary

1. Growers in West Bengal usually prefer tall suckers, well over 5 feet in height, to smaller ones for planting banana, as the latter are more prone to damage from stray cattle. Transport of big suckers is difficult and expensive in rural areas, particularly during rainy season, where all-weather roads do not exist. Pruning of suckers before planting could minimise the transport cost. The present investigations were undertaken to find out the optimum size of suckers and the effect of pruning them before planting on growth, yield and grade of fruit.

2. A randomised trial with 4 replications was conducted at Krishnagar on *Champa*, a commercial variety of the State. Suckers of three sizes, viz. 3 feet, 4 feet and 5 feet, were planted with leaves pruned only, and headed back one foot and 2 feet from top.

3. The 5-foot suckers gave superior growth only in the initial stages, the difference in growth among the various suckers ultimately becoming nonsignificant.

4. Heading back of suckers caused only a temporary check in growth in the 3-foot and 5-foot suckers, whereas it did not produce any significant effect on the 4-foot suckers.

5. Height and heading back of suckers had a marked influence on maturity, i.e., the period from planting till harvest. The 5-foot suckers with leaves pruned only matured in the shortest time of all the treatments. Heading back of the 5-foot suckers 2 feet from top delayed maturity, whereas there was no significant effect on the 3-foot and 4-foot suckers.

6. The yield and number of hands per bunch were not affected by the height and heading back of suckers. The number of fingers per bunch was found variable.

7. The results are discussed. It is concluded that 3-foot, 4-foot and 5-foot suckers are equally good for planting, the only difference being that the 5-foot suckers mature earlier than the former. Where transport is a problem, smaller suckers should be preferred, for heading back of tall suckers (5-foot) for convenience in handling has the definite disadvantage of delayed maturity. These recommendations are likely to hold good for other tall varieties, such as *Martaman*, *Kanthali*, *Beula* (a cooking variety), etc., commonly grown in the State.

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RESPONSES OF RAGI (*ELEUSINE CORACANA*, GAERTN) TO VARYING CONCENTRATIONS OF BETA-NAPHTHOXY ACETIC ACID

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(With 2 Text-Figures)

AUXINS have been used in the agricultural field to determine whether they affect the maturity and result in increased yield of crops, but with inconsistent results. Asana *et al.* [1955] have found that auxins produce greater yield, though this is not consistent from year to year. But, as Sen Gupta [1955] has pointed out that most of the available information is of little use, these experiments were undertaken as a preliminary study to see whether some of these substances brought about the favourable changes which the agriculturists welcome.

Material and Methods

Healthy seeds of *rayi*, variety K.1, were soaked for 24 hours in aqueous solutions of beta-naphthoxy acetic acid (NoXA) of 0·2, 0·4, 0·6, 0·8 and 1·0 parts per million (ppm) at room temperature (29°C to 32·8°C). Controls were soaked in tap water. The seeds were then sown in earthenware pots of size 8ft.×8ft. filled with soil prepared by mixing 2 parts of garden soil, 1 part each of sand and cowdung and sheep manure and ¼ oz. each of ammonium sulphate and superphosphate per pot, potassic manure being avoided as the soil here is rich in this element. After one month another doze of ¼ lb. of cowdung was added to each pot so that nutritional factors may not be limiting. After the first fortnight the plants were thinned down to 4 in each pot and 4 such pots were maintained under each treatment. At flowering time a top dressing of ¼ oz. each of ammonium sulphate and superphosphate was also made to each pot.

Every fortnight fresh application of the acid was made to the aerial parts as sprays of the aqueous solutions by using the flit sprayer, approximately 5 cc. being sprayed on each plant, till the plants flowered. Observations of height, the number of leaves and tillers were made each fortnight and also the length of the vegetative period.

After maturity, the yield and its components were determined. The number of spikelets and percentage of grain set were determined only for the main panicle. The weight of straw was also determined. The data were analysed using the analysis of variance method with 5 degrees of freedom for between and 90 degrees of freedom for within treatments.

The meteorological conditions obtaining during the period were : maximum temperature varied from 94°F to 75·3°F and the minimum temperature from 78·5° to 44·2°F from August to December, 1955, relative humidity from 75 to 86 per cent in the mornings and 36 to 67 per cent in the evenings during these months while the rainfall was 4·74 inches in August, 2·75 inches in September, 5·36 inches in October, *nil* in November, and 0·21 inch in December.

Observations

In the first fortnight the growth attained by the plants is not consistent with the concentrations of the acid nor is there any difference in the leaves borne (Table I). In the succeeding two fortnights the treated plants attain more height which is significant over the control at 1 per cent level, as also the number of leaves. Tillers and lateral branches are inhibited by the auxin (Table II), the inhibitory effect increasing as the concentration increases (Fig. 1).

Flowering has been hastened by 7·37 to 12·67 days and dry matter increases by the treatments (Table I). The plants at the fruiting stage are shown in Fig. 2.

The yield and its components are given in Table II, and the analysis of variance in Table III. The number of panicles is reduced as the concentration of the acid is raised. But, the length of panicles, total grain weight, weight of 1,000 grains and the number of spikelets, grains and percentage of grain set (in the main panicle only) are all considerably greater than the control and are proportionate with the concentration changes the 1·00 ppm treatment producing 53·7 per cent more grains.

From the analysis of variance it is clear that the treatments are significant at 1 per cent level over the control.

Discussion

Applying hormone solution to the soil [Allard *et al.* 1946], presoaking of seeds alone [Bharadwaj and Rao 1955], dusting of seeds [Hopkins 1940], vapour treatments of seeds [Mullison and Hummer 1949], applying them as sprays of aqueous solution or as lanolin paste or injecting them into leaves [Asana and Mani 1951] have been tried by various investigators in this field. Here, the seeds were presoaked in the auxin solution and its application continued as sprays to the vegetative parts till the plants flowered.

In the initial stages the effect of the auxin on growth is not consistent with the increase in concentration as has been reported by Pillai and Kurup [1956-b]. But in the second and third fortnights its application as spray brings about a very pronounced increase in height when the peak is reached, while in the control the peak is reached only during the third and fourth fortnights. The effect of the auxin seems to be, therefore, to enable the plants to reach their peak growth earlier than normal thus ending the vegetative phase and ushering in the reproductive phase earlier.

Fig. 1.—Ragi plants treated with verious concentrations of NoXA before ear emergence

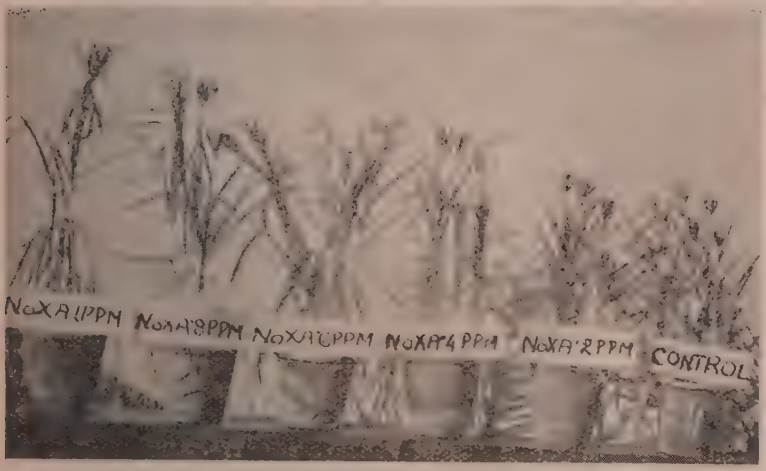

Fig. 2.—Ragi plants treated with various concentrations of NoXA at maturity

TABLE I

Height, number of leaves and tillers, vegetative period and dry matter produced by ragi plants treated with NoXA

(Average of 16 plants)

Observations	Control	Treatments					S.E. of Means	C. D. at 1 per cent level
		0·2	0·4	0·6	0·8	1·0		
I Fortnight—								
Height (ins.)	1·5	1·6	1·66	1·62	1·6	1·66	0·024	0·0968
Leaves (no.)	2	2	2	2	2	2		
Tillers (no.)	—	—	—	—	—	—		
II Fortnight—								
Height (ins.)	2·5	8·0**	8·35**	9·07**	9·15**	9·20**	1·061	4·274
Leaves (no.)	3·4	5·5	6·0	6·1	6·2	6·4	0·498	2·008
Tillers (no.)	—	—	—	—	—	—		
III Fortnight—								
Height (ins.)	14·4	20·64**	21·12**	23·21**	25·2**	25·38**	1·680	6·774
Leaves (no.)	9	10·2	10·3	10·5	10·5	11·0	0·274	1·105
Tillers (no.)	0·2	—	—	—	—	—		
IV Fortnight—								
Height (ins.)	21·8	23·88	25·78*	27·33**	29·44**	30·35**	1·33	5·363
Leaves (no.)	11·5	15·2	15·2	15·4	16·1	19·0	0·98	3·951
Tillers (no.)	0·2	—	—	—	—			
Ear Emergence (Days)	86·07	78·7	76·6	76·0	74·2	73·4	1·83	7·379
Dry matters (gms.)	5·49	5·52	5·74	6·01	6·24	6·42	0·15	0·605
Percentage of dry matter on control	100	102·3	104·7	109·3	113·7	116·9		

* and ** indicate values which are significant over control at 5 per cent and 1 per cent level respectively.

TABLE II

Components of yield of ragi plants treated with NoXA

(Average of 16 plants)

Observations	Control	Treatments					S.E. of Means	C.D. at 1 per cent level
		0·2	0·4	0·6	0·8	1·0		
Panicles per plant (no.)	1·8	1·19	1·19	1·15	1·0	1·0	0·121	0·4879
Length of panicles (cm.)	2·84	2·86	2·86	2·88	2·92	3·34	0.0787	0·3173
Grains in main panicle (no.)	931·7	941·4	1030·3	1111·6	1262·5 *	1274·5 *	52·2	210·47
Spikelets in main panicle (no.)	1179·4	1184·3	1232·7	1300·5	1453·9	1562·2	64·0	253·05
Percentage of grain set in main panicle	79·21	82·93	83·28	85·33	86·94	87·90		
Grain weight per plant (gm.)	2·40	2·59	2·78	2·90	3·43	3·69	0·203	0·8185
Percentage of grain weight on control	100·0	107·91	115·8	120·8	142·9	153·7		
Weight of 1,000 grains (gm.)	2·57	2·59	2·61	2·65	2·73	2·89	0·049	0·1976

* indicate values significant over control at 5 per cent level.

TABLE III

Analysis of variance on the data on grain yield

Source of variation	Degrees of freedom	S.S.	M.S.	F		
				observed	from tables	
					5 per cent	1 per cent
Between	5	19·8448	3·9889	5·23	2·31	3·20
Within	90	71·7430	0·755			

Presoaking has not affected the leaf production in the early stage. But subsequent applications during the vegetative period have had the effect of increasing leaf production, which is proportionate with the concentration changes. These observations are similar to those of Bharadwaj and Rao [1955], though their technique is different.

Ragi bears lateral branches on the aerial shoots which end in panicles and the number of panicles gives an indication of such branches. The production of these is found to be inversely proportional to the concentration changes (Table II). Leopold and Thimann [1949] have pointed out that the formation of vegetative buds was not promoted by auxins, while in contrast, Asana *et al.* [1955] have found increased production. The effect of the auxin, as far as this is concerned, is not favourable.

Observations on the effect of hormones in inducing early flowering in various plants by different authors differ. Harland [1953], Sen Gupta [1955] and others have pointed out that, except in the pineapple, hormones have not resulted in initiating the reproductive phase earlier. This is a factor of great importance to Rajasthan, where the growing season is short and where any method of reducing the duration of a crop without jeopardising the yield will be of great advantage. Leopold and Thimann [1949] found that this is really an effect of auxin concentration, the lower concentrations promoting flowering. Chakravarti and Krishna Pillai [1955] and others have found evidences which concur with this. But, Sen and Joshi [1954], and Pillai and Kurup [1956-a] have found that auxin prolongs the vegetative cycle. In the treatments under discussion it is found that they reduce the vegetative cycle, this reduction progressing with increase in concentration. It is to be pointed out that the concentrations of the acid used were very low. The difference in the days of emergence is quite noteworthy, the treatment with 1·0 ppm maturing 12·67 days earlier. The tendency to reproductive development seems to depend upon the concentration of the auxin in the plant. Since only sub-micro-concentrations have been tried here, the increase in concentration of the auxin applied externally naturally increases its concentration inside the plant, which results in inducing earliness in flowering.

Dry matter. The auxin is found to produce an increase in dry matter, the greatest increase, 16·9 per cent, being observed in the 1·0 ppm treatment (Table I). Beneficial effects have been observed in straw production by Hopkins and others [1940] by dusting the seeds and by Bharadwaj and Rao [1955] by presoaking seeds in low concentrations of auxins. The tendency exhibited here, viz., increased straw production, if found under field conditions, would aid in solving the fodder problem of a State like Rajasthan to a great extent.

Grain yield. Though the number of panicles is decreasing with increasing concentration of the auxin, the grain yield per plant is found to increase progressively, the treatment with 1·0 ppm producing 53·7 per cent more grains than the control (Table II). Asana *et al.* [1955] have found a promotive effect of auxin on spikelet differentiation. Our results show that the increase in yield is directly correlated with the increase in straw, as seen by Leopold and Thimann [1949].

It is to be noted that though these plants exhibit greater straw weight, height and yield, their life duration is considerably less than the control. This shows that their synthetic metabolic activities are considerably accelerated by the application of auxins.

The analysis of variance shows that such treatments can result in definite increase in grain yield under similar conditions because the length, number of spikelets and the percentage of grain set are increased in the panicles. Also the grains get filled better in them as is shown by the weight of 1,000 grains.

Summary and Conclusions

The effect of presoaking of seeds and subsequent application of NoXA as sprays on the aerial parts of ragi plants on growth, maturity and yield of grains and straw are recorded. The auxin influences the development of the plants to a considerable extent. The general effect is to promote vegetative and reproductive development, the effect being directly proportional to the concentration. It produces better height, more leaves, greater dry weight and earlier flower initiation, though tillering and lateral branches are inhibited. Reproductive growth is also favourably influenced by the treatments as is manifested by greater grain yield, larger panicles, higher precentage of grain set and better filling of grains.

The general effect of NoXA used as sprays of aqueous solution following soaking of seeds is of benefit.

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STUDIES WITH FENUGREEK (*METHA*) IN THE PUNJAB

By H. C. Malik and P. C. Batra

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(With 1 Text-figure)

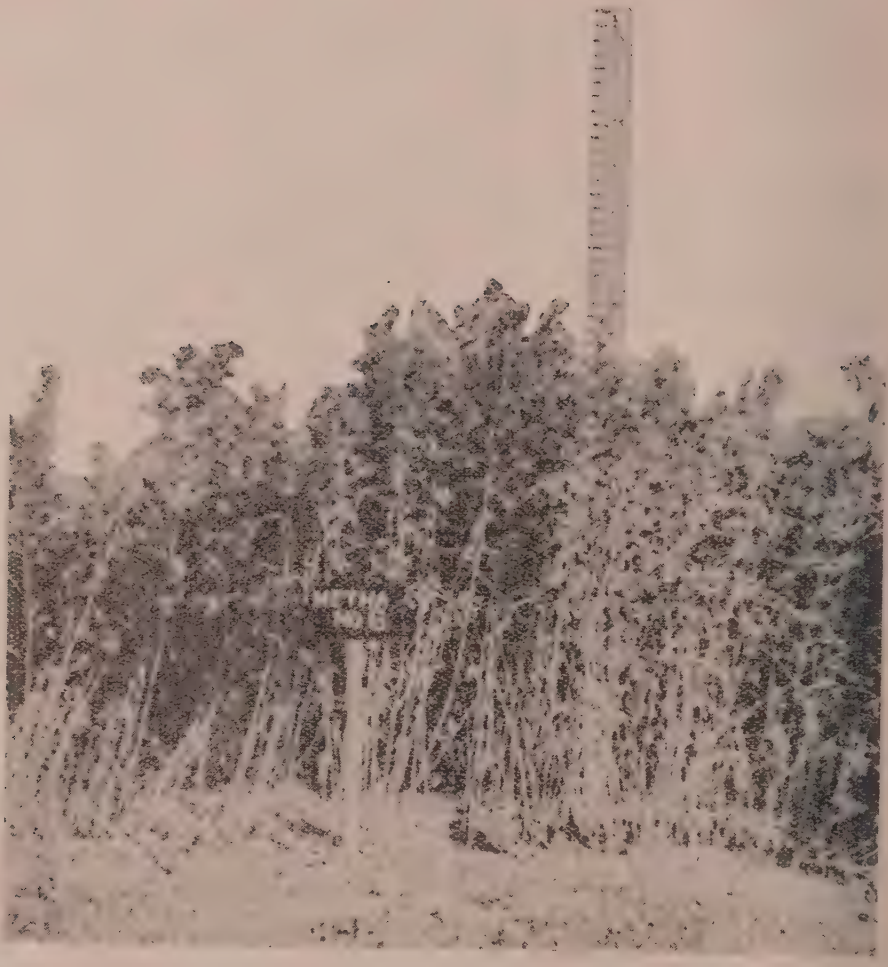
'Metha' (*Trigonella foenum-graecum*) is an important indigenous legume primarily for forage in the *rabi* seasons under conditions where moisture is limited either for berseem (*Trifolium alexandrinum*) or 'senji' (*Melilotus parviflora*) which are sown in standing water. It serves as a very good catch crop [Fodder Anonymous 1951] especially after sugarcane or when it is grown in standing crops of cotton or chillies. Not only that its green forage is useful for cattle, its seed also possesses great medicinal properties and is largely used as a condiment. The crop is cultivated everywhere generally but constitutes an important forage crop in the districts of Ambala, Rohtak, Ludhiana and Hoshiarpur in the State.

According to the recent figures of acreage of fodder crops in the State, it is grown on an area of 54,678 acres which is about 2·14 per cent of the total area under fodder crops. The area is gradually decreasing and is giving place to berseem as irrigation facilities are improving with the extension of canal irrigation or installation of tube wells. *Metha* crops is generally grown under irrigation but quite good crops have been observed in the high rainfall areas of Ambala and Hoshiarpur without irrigation. *Metha* is often sown alone, but sometimes mixed with other legume, viz. *senji* or non-legumes as oats, etc.

Being a legume, it thrives best on well drained loam soils rich in lime. As a main crop, it is sown in the months of October-November but sowings can be made as late as December in mixture with oats, etc., for forage. As a catch crop, it is sown after harvesting sugarcane. The main forage crop is ready for harvest in February-March in about 3-4 months after sowing with two or three irrigations during the growing period. The late sown catch crop, however, does not make much vegetative growth and is, therefore, allowed to set seed which ripen in the end of April.

The green forage is highly nutritious and sustaining and is considered useful especially for buffaloes. Seed is commonly used in the preparation of pickles and condition powder for horses and buffaloes. The leaves of the young plants are used for cooking purposes. The feeding analysis of the crop in comparison with other *rabi* legumes as reported by Sen [1952] is given in the Table I.

Table I shows that *metha* contains quite high percentage of crude protein which is slightly less than *senji* but is almost half as much as that of berseem and lucerne. Because of its characteristic odour it is much relished by cattle.



A crop of Metha No. 8 which give highest forage yield of 403·3 maunds per acre.

TABLE I

Nutritive value of various rabi *legumes*

Crop	Organic constituents			Digestible nutriants per 100 lb. of raw material			N.R.
	Crude Protein	N.E.E.	E.E.	Dig. crude protein	Starch equivalent	Total digestible nutriants	
Berseem	23·10	46·94	2·78	2·82	11·0	12·9	3·6
Lucerne	26·60	46·23	2·63	3·24	9·7	12·0	2·7
Senji	15·46	41·95	1·47	2·52	10·3	12·8	4·1
Metha	12·12	39·95	1·70				

According to Piper [1937], this legume is a native of Mediterranean region of Europe but extends to the Central Asia and North Africa. As a cultivated crop, it is mainly grown in India and Turkey. It is also an important forage crop in Italy and Egypt.

The crop is grown in the Punjab since long but work with a view to find out definitely superior varieties of the crop was undertaken with the establishment of the Fodder Research Section. To start with material was collected from the different parts of the State and isolated into definite types.

REVIEW OF LITERATURE

Mckee and Pieters [1937] while reporting on miscellaneous forage and cover crop legumes of U.S.A. state, 'So far as known no special improvement in work has been done in any country on Fenugreek (*Trigonella foenum-groecum*). The varietal differences observed in this crop are probably the result of natural regional development rather than artificial selection. At the California Agricultural Experimental Station at Davis the continued propagation for years of one of the best introduced strains of fenugreek appears to have resulted in the development of a superior variety well suited to at least that part of the State'.

Hector [1936] reports that out of 70 species of the genus Trigonella, one species *Trigonella Foenum-groecum* (Fenugreek) is grown to a limited extent as a forage plant. He described it as an annual, 1 to 2 feet in height, pubescent and markedly scented, leaves trifoliate with obovate leaflets three-fourth of an inch to 1 inch long and obscurely denticulate towards the apex, flowers solitary in pairs in the leaf axils and practically sessile, calyx has 5 subulate hairy lobes, corolla, white, pods are 3 to 6 inches long, very slender and curved, many seeded with a beak 1 to 2 inches long.

Piper [1924] describes fenugreek as an erect plant with usually several stems from the same root, leaves clover like, pods long and pointed, successful near the sea coast and citrus districts of California State. Yields of 15,518 lb. of green fodder were recorded to an acre.

Material and Methods

Samples of *metha* seed from different *metha* growing areas of the State had been collected through the local staff of the Agriculture Department a number of years earlier to 1948-49. Efforts were also made to obtain seed from all the other main *metha* growing areas. These samples were sown in separate lines 2 feet apart keeping a distance of about 6 inches from plant to plant in order to study the variants in each sample. Different plants were isolated from each sample line and intensive study was made of their agro-botanical characters. Their seeds were grown in progeny rows for further observations. The rows showing resemblance in appearance as well as in their morphological characters were grouped in different groups according to the key given in the text and a tentative classification was carried out. A representative plant from each group was selected and sown according to the tentative classification. The classified material was once again subjected to intensive recording of botanical characters and after making required adjustments, the classification was confirmed. The classified types were sown in a replicated progeny row test for evaluation of their fodder and seed yielding capacities. The best fodder types were included firstly in small scale trials and later on in large scale trials. The work of classification and evaluation was actively taken from the year 1948-49 and completed in 1952-53.

Experimental Results and Discussion

(i) *Characters used as a basis for classification*

The agro-botanical characters described herein are well developed specific differences which can more or less safely be relied on as definite and constant features under all conditions existing in different parts. But when considering a comparison between varieties, it is necessary to give full weight to variations existing in these, as a result of varying conditions of soil and climate under which they are grown. The characters which have been used to serve as a basis for the present classification are given below :

Habit of growth. In the early stages of growth *metha* plants may be grouped into semi-erect and semi-spreading but this difference is not very distinct in the mature plants when all the types assume more or less erect habit. This character has, therefore, very limited application in classification.

Size of leaf. *Metha* plant has pinnately trifoliate leaves which are denticulate and have adnate stipules. Although there is wide variation in the size of leaves on the same stem yet there exists an appreciable difference between the general size of leaflets of different types. In order to find out the average variation in the dimensions of leaflets, left leaflet of fifth leaf counting from the top was measured in each type.

Colour of leaf. The colour of vegetation is susceptible to a good deal of variation and is very easily influenced by growth. But under a set of uniform conditions of environment, there are clear cut differences in some of the types studied with regard to this character. There are types with dark green leaves. These have been described as dark green as contrasted with the light coloured ones termed light green. The intermediate between dark and light is a bit difficult to diagnose because personal factor operates to a great degree in the right expression of this character. Some of the types have yellowish tinge whereas some have got purple tinge and thus have been described as such.

Height. This again is a character which varies within very wide range and is influenced by the climate and growth factors. There is, however, distinct difference in the average height of some of the types.

Thickness of stem. Thickness of stem has been measured in order to differentiate between fine stemmed and coarse stemmed types.

Maturity. Maturity has been measured by the number of days taken from seeding to the beginning of flowering. This has been recognised as the most important character in the present investigations. It is a well known fact that the duration of a crop depends to a great degree on the time of sowing. In the Punjab State *metha* is generally sown in the end of October or the beginning of November and the number of days taken from that date till the appearance of first flowers has been taken as an index of maturity rather than the actual date of ripening, because ripening is materially influenced by weather conditions. In the present study, types which took 50-58 days to flower were termed early, those which flowered from 59 to 66 days and 67 to 77 days were called medium and late respectively and those which took 78 or more than 78 days were classed as very late.

Pod characters. In all types of *metha* isolated in the Punjab, the pods are solitary as well as in pairs on the same shoot. Their average size, however, varies in different types. Length and breadth of pods and length of beak have been measured in all types and recorded in the present description.

Grain weight. Weight per 1,000 grain is one of the important criterions for judging quality and size of grains. This character was, therefore, recorded in all types.

Description of types

The material has been classified into 19 distinct types on the basis of the above characters. The description is given in Table II.

TABLE II

Description of types on the basis of characters

Type	Height	Thickness of stem (cm.)	Size of leaflets (cm.)	Colour of leaves	Days taken to flower	Pods size length and breadth	Beak (cm.)
Early flowering :—							
1. Erect, medium	80·92±1·81	Thick 0·406±0·007	2·38×1·28	Dark green	Early—50 days	9·38±0·17 0·423±·0112	2·53±0·102
2. Erect, medium	87·43±1·78	Thick 0·424±0·0078	2·62×1·39	Dark green	Early—53 days	10·35±0·17 4·25±0·0067	2·61±0·075
3. Erect, medium	80·26±1·60	Thick 0·418±0·011	2·32×1·20	Green	Early—54 days	9·96±0·23 0·472±0·005	2·67±0·072
4. Erect, medium	80·88±1·50	Fine 0·382±0·0084	2·44×1·16	Green	Early—55 days	10·03±0·27 0·438±0·0065	3·15±0·076
Medium flowering :—							
5. Erect dwarf	72·25±1·82	Fine 0·385±0·0072	2·44×1·49	Light green	Early—58 days	11·13±0·23 0·468±0·0072	3·36±0·093
6. Semi-erect dwarf	93·32±2·23	Fine 0·398±0·0097	2·25×1·32	Light green with purplish tinge.	Medium—60 days	11·48±0·33 0·435±0·057	3·58±0·060
7. Semi-erect	76·55±1·46 Dwarf	Fine 0·358±0·008	2·06×0·99	Do.	Medium—62 days	8·85±0·22 0·43±0·010	2·92±0·054
8. Semi-erect	96·89±0·96 Tall	Thick 0·404±0·0085	2·29×1·33	Dark green with purple top.	Medium—63 days	10·09±0·022 0·437±0·0053	3·08±0·063
9. Semi-erect	78·10±1·08 Dwarf	Fine 0·372±0·0043	2·19×98	Dark green	Medium—63 days	8·67±0·19 0·437±0·0057	3·02±0·057
10. Semi-erect	78·26±1·42 Dwarf	Fine 0·372±0·0077	2·37×1·23	Green	Medium—66 days	9·9±0·22 0·387±0·068	3·07±0·094

TABLE II—*contd.*

Description of types on the basis of characters

Type	Height	Thickness of stem (cm.)	Size of leaflets (cm.)	Colour of leaves	Days taken to flower	Pods size length and breadth	Beak (cm.)
Late flowering :—							
11. Semi-erect	97·59±2·15 Tall	Thick 0·446±0·0085	2·19×1·27	Dark green	Late—71 days	9·83±0·30 0·437±0·0063	2·29±0·076
12. Semi-spreading to semi-erect	88·38±2·04 Medium	Fine 0·383±0·0075	2·13×1·14	Dark green	Late—72 days	10·23±·020 0·441±0·0062	3·09±0·68
13. Semi-spreading to semi-erect	81·61±1·44 Medium	Fine 0·344±0·0064	1·75×1·09	Dark green	Late—72 days	8·87±0·17 0·482±0·0042	2·66±0·065
14. do.	88·79±1·71 Medium	Fine 0·334±0·0048	2·01×1·06	Green	Late—73 days	7·81±0·22 0·412±0·0056	2·56±0·063
15. Semi-erect	82·13±1·36 Medium	Fine 0·369±0·0068	2·39×1·20	Dark green	Late—74 days	9·97±0·23 0·402±0·0053	3·04±0·084
16. Semi-spreading to semi-erect	84·7±2·23 Medium	Fine 0·395±0·016	2·27×1·36	Green	Late—76 days	10·37±0·15 0·433±0·0034	2·55±0·046
17. do.	88·73±1·48 Medium	Thick 0·425±0·0095	2·19×1·26	Green	Late—76 days	10·47±·018 0·444±0·0063	2·76±0·044
Very Late :—							
18. Semi-spreading to semi-erect	92·97±3·10 Tall	Thick 0·493±0·0086	3·35×2·14	Broad lobed dark green, with purplish tinge.	Very late 81 days	12·17±0·19 0·575±0·0110	3·21±0·091
19. Spreading to semi-spreading	68·40±1·50 Dwarf	Fine 0·326±0·0057	1·66×86 very small	Dark green	Very late 81 days	9·58±0·24 0·443±0·0079	3·23±0·072

Performance of metha *types*

Side by side with the classification work, these types were also subjected to evaluation of fodder yield in replicated tests. The preliminary test consisting of all the types and laid out on rod row basis in the year 1949-50 and comparative trials of the best types laid out in the subsequent years from 1950-51 to 1954-55 gave the following results :—

Year	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55
Size of plot		1/175th	1/80th	1/113th	1/100th	1/100th
No. of replications	5	4	6	5	6	6
Date of sowing	13-10-49	15/10	31/10		18/10	2/11
Date of harvesting	22/2 to 3/3	9/3 to 17/3	29/2 to 17/3		13/2 to 16/3	11/3 to 21/3

Yields per acre in maunds

Type	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	Average
1	313·7						
2	311·1						
3	298·1						
4	..						
5	..						
6	..						
7	290·45						
8	412·2	300·7	440·0	496·1	465·4	305·8	403·3
9	299·4						
10	..						
11	344·8	298·1	458·0	473·4	435·4	302·8	382·1
12	298·1						
13	241·1						
14	308·5						
15	355·2	266·8	442·0	442·0	..	..	376·5
16	329·2	273·4	432·0	447·9	432·5	283·6	368·1
17	303·3						
18	..						
19	261·8						
CD 5 per cent	61·3	86·1	33·9	60·8	23·2	26·1	
CD 1 per cent	81·2	120·7	46·2	98·0	32·5	36·1	

From these results it will be observed that *Metha* No. 8 gave the highest forage yield of 403·3 maunds per acre, with No. 11 as its close second yielding 382·1 maunds per acre. Hence two types No. 8 and No. 11 were found to be the best out of all 19 types of Punjab *Metha*.

SUMMARY

In this article results of the sudy of Punjab *metha* varieties are given. Samples of the legume from the whole State were subject to intensive study and as a result 19 pure types were isolated. They have been described. The fodder yield trials of the promising types revealed the superiority of No. 8 followed by No. 11 over all others.

No. 8 has been recommended for cultivation by the State Department of Agriculture in the Punjab State.

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STUDIES ON THE PROPORTIONATE LARVAL POPULATION OF THE DIFFERENT SPECIES OF PADDY STEM-BORER IN WEST BENGAL

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(With 2 Text-Figures)

In West Bengal, paddy plantation is subject to the attack of three different species of lepidopterous larvae, viz., *Schoenobius incertulas* Wlk., *Proceros indicus* Kapur., and *Sesamia inferens* W. Of these, *S. incertulas* solely depends on paddy to complete its life-cycle. The other two *P. indicus* and *S. inferens* being also the pests of sugarcane, do not depend entirely on paddy to complete their life-cycle. As the larvae of these insects live inside the paddy stem, they are all called paddy stem-borers. The attack by any of these stem-borers in the young stage of the crop is followed by the formation of "dead heart" due to the drying up of the central shoot. The attack in the late stage of the crop prevents grain formation in the ear-heads resulting in "white heads". The differences in the species has no bearing in the symptoms of damage and as such it is not possible to identify the incidence of any of the particular species without dissecting the damaged sample of the paddy crop. It was, therefore, thought to be interesting to make an attempt to find out the proportionate larval population of *S. incertulas*, *Proceros indicus* and *Sesamia inferens* in the damaged sample of *aman* paddy plants. The experiment was carried out in the farm of the State Research Station, Chinsura, Hooghly, a place situated 23 miles north of Calcutta. The experiment was conducted for 4 years covering from 1951 to 1954.

Material and Methods

The lay-out of the experiment was simple and consisted of 4 blocks. Each block measured 120 ft.×60 ft. The blocks were kept scattered in the farm with distance of approximately 200 ft. from one another. The paddy variety selected for the experiment was *Bhasamanik*. For the experimental observation a sample of 300 damaged paddy plants were uprooted at random from each block and they were then dissected in the laboratory. The species of larvae found inside the dissected sample was taken out, identified and grouped properly. The dissections of uprooted paddy plants were continued till 250 positively damaged plants were recorded in each block and after that was over, the outstanding balance of the collected sample was rejected. The samples of damaged paddy plants were similarly collected from the three other replicates and the data were collected on the same method. The experimental results based on 1,000 damaged plants as well as the observations of the 4 years are tabulated in the Table I. The observations

have also been depicted in histogram and are shown in the Figs. 1 and 2. In plotting the histogram, (Fig. 2a) the average of the aggregate values of 4 years shown in the last column of the Table I were considered.

Results and Discussions

The species of lepidopterous insects recorded as paddy stem-borer are different in the different paddy growing countries. Kawada *et. al.* [1954] have described, *Schoenobius incertulas* Wlk., *Sesamia inferens* Wlk., and *Chilo simplex* Butler., to be the stem-borer of paddy in Japan. Engel Hardt [1927] has observed *Chilo simplex* Butl. and *Schoenobius* sp. in the stem of paddy in Russia. Hadden [1928] has described *Schoenobius incertulas* Wlk., and *Chilo simplex* Butl. to be the stem-borer of paddy in Formosa. Pagden [1930] has noted *Diatraea auricilia* Dudg., *Schoenobius incertulas* Wlk., and *Sesamia inferens* Wlk. to be the stem-borer of paddy in Malaya. Van Der Goot [1925] has described *Scripophaga innotata* Wlk., and *Schoenobius incertulas* Wlk., to be rice-borer in Java. Otanes and Sison [1952] have described *Scripophaga innotata* Wlk., and *Schoenobius incertulas* Wlk. and *Chilo simplex* Butl. as rice stem-borer in Philippines. Mo [1955] has informed, the insects *Schoenobius incertulas* Wlk., *Sesamia inferens* Wlk., and *Diatraea venosata* to be the stem-borer of paddy in Indonesia. In West Bengal the different lepidopterous species noted to damage the paddy crop are *S. incertulas*, *P. indicus* and *S. inferens*.

Table I, gives the proportionate incidence of the three species of the paddy stem-borer. Now in studying result of 1951, it is seen that the size of the larval population of *S. incertulas*>*S. inferens*>*P. indicus* and in the ratio of 2·6:1 between *S. incertulas* and *S. inferens*; 3·3 : 1 between *S. incertulas* and *P. indicus* and 1·2 : 1 between *S. inferens* and *P. indicus*. The data of the year 1952 show that the size of the larval population of *S. incertulas* is greater than the other two species of insect, but unlike previous year *P. indicus*>*S. inferens*. The ratio of the larval incidence between *S. incertulas* and *P. indicus*, *S. incertulas* and *S. inferens*, and *P. indicus* and *S. inferens* are 1·4 :1, 3·6 : 1 and 2·5 : 1 respectively. The observations of the year 1953 show that the size of the larval population of *S. incertulas*> *S. inferens*>*P. indicus* like the data of the year 1951 and the ratio between *S. incertulas* and *S. inferens*, *S. incertulas* and *P. indicus* and *S. inferens* and *P. indicus* are 2·5 : 1, 2·9 : 1 and 1·1 : 1 respectively. The result of the year 1954 is similar to the result of the year 1952, i.e., the size of the population of *S. incertulas*>*P. indicus*>*S. inferens*. The ratio maintained amongst the three species of insects are 1·2 :1, 1·4: 1 and 1·1: 1 between *S. incertulas* and *P. indicus*, *S. incertulas* and *S. inferens*, and *P. indicus* and *S. inferens* respectively.

In a critical study of the Table I, it will be seen that the size of the larval population of *S. inferens* were greater to *P. indicus* during the seasons 1951 and 1953; whereas in the other two seasons 1952 and 1954 the size of the larval population of *P. indicus* were greater than *S. inferens*. But in aggregating the results of four years together (Table I, last column) it becomes evident that the size of the larval

Table I

The percentage of larvae of the different species of paddy stem-borer during four years of the experimentations

Name of paddy stem-borer	Code mark	Replications	Proportionate population of larvae per year								Average of four years	Mean
			1951	Mean	1952	Mean	1953	Mean	1954	Mean		
Schoenbius incertulas	A	I	64·0	59·7	48·8	50·3	58·8	58·0	40·8	40·4	52·9	52·3
		II	57·2		50·8		61·2		39·2		52·9	
		III	59·6		56·0		52·0		43·6		52·8	
		IV	58·0		45·6		60·8		38·0		50·6	
Proceros indicus	B	I	13·6	17·6	30·4	35·8	19·6	19·6	32·0	32·3	25·4	26·2
		II	19·2		35·6		18·8		33·2		26·7	
		III	20·4		32·0		22·8		30·4		26·4	
		IV	17·2		39·2		17·2		33·6		26·1	
Sesamia inferens	C	I	22·4	22·7	14·8	13·9	22·4	22·4	27·2	27·3	21·7	21·3
		II	23·6		13·6		20·0		27·6		21·2	
		III	20·0		12·0		25·2		26·0		19·8	
		IV	24·8		15·2		22·0		24·4		22·6	

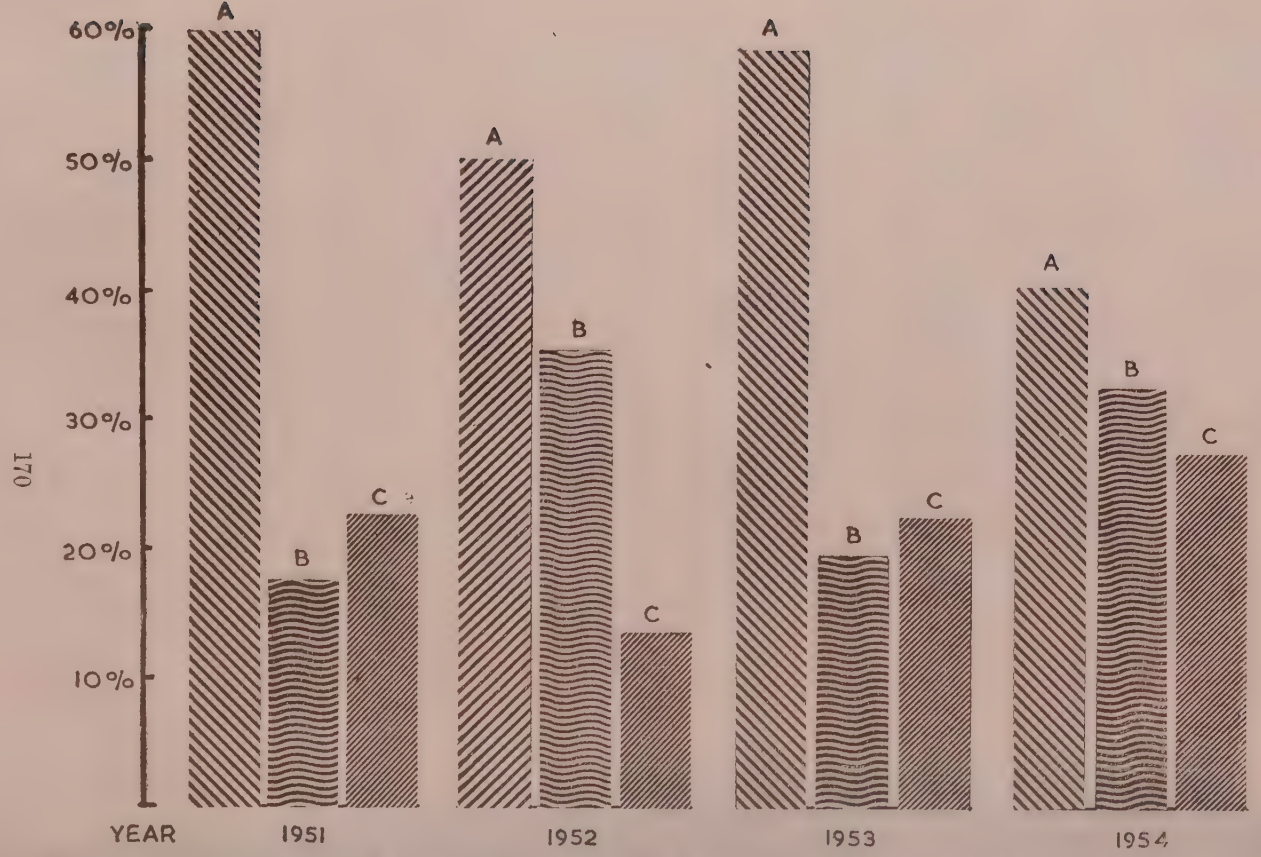

Fig. 1.—Histogram showing the percentage of larvæ of (A) *S. incertulas*, (B) *P. indicus* and (C) *S. inferens* in the stem-borer damaged paddy plants plotted on the data of the individual year.

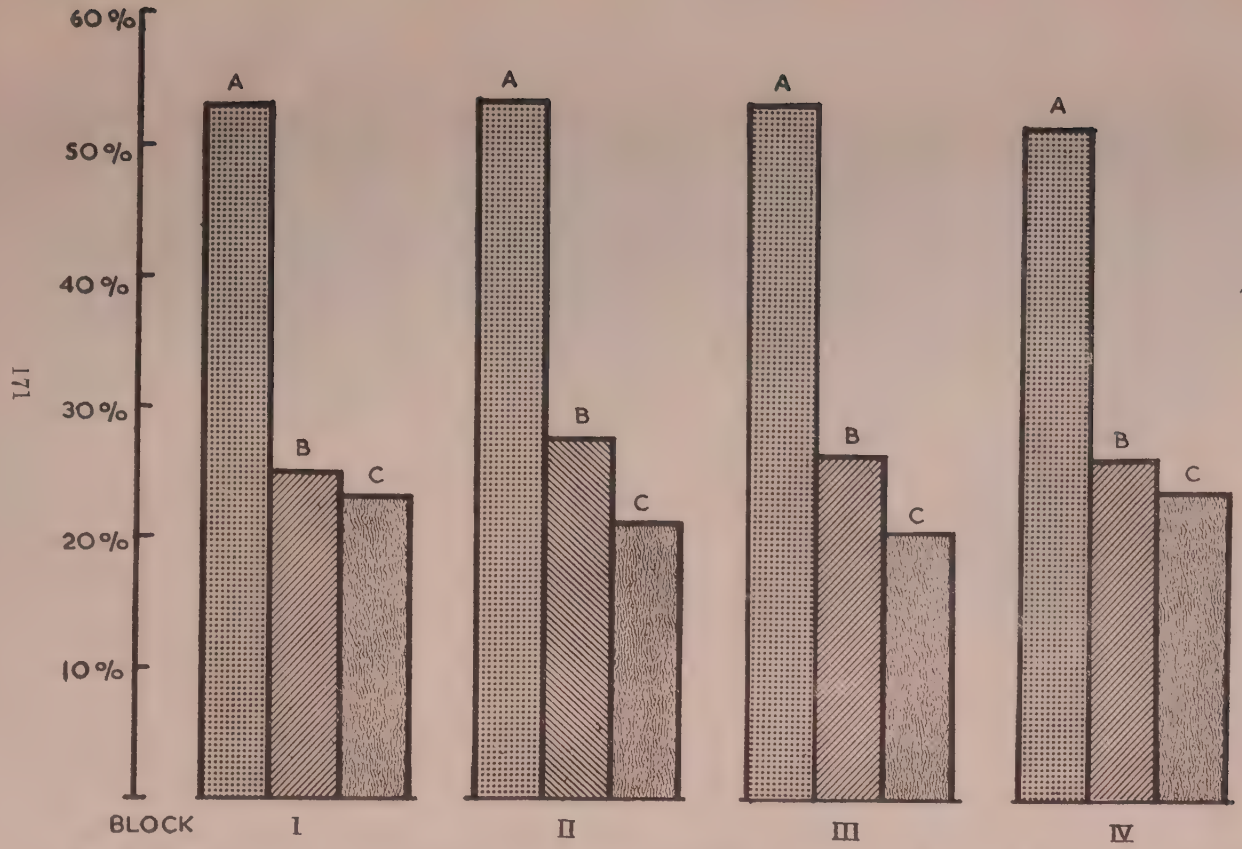

Fig. 2.—Histogram showing the percentage of larvæ of (A) *S. incertulas*, (B) *P. indicus* and (C) *S. inferens* in the stem-borer damaged paddy plants plotted on the observations of four years' average of the individual experimental block.

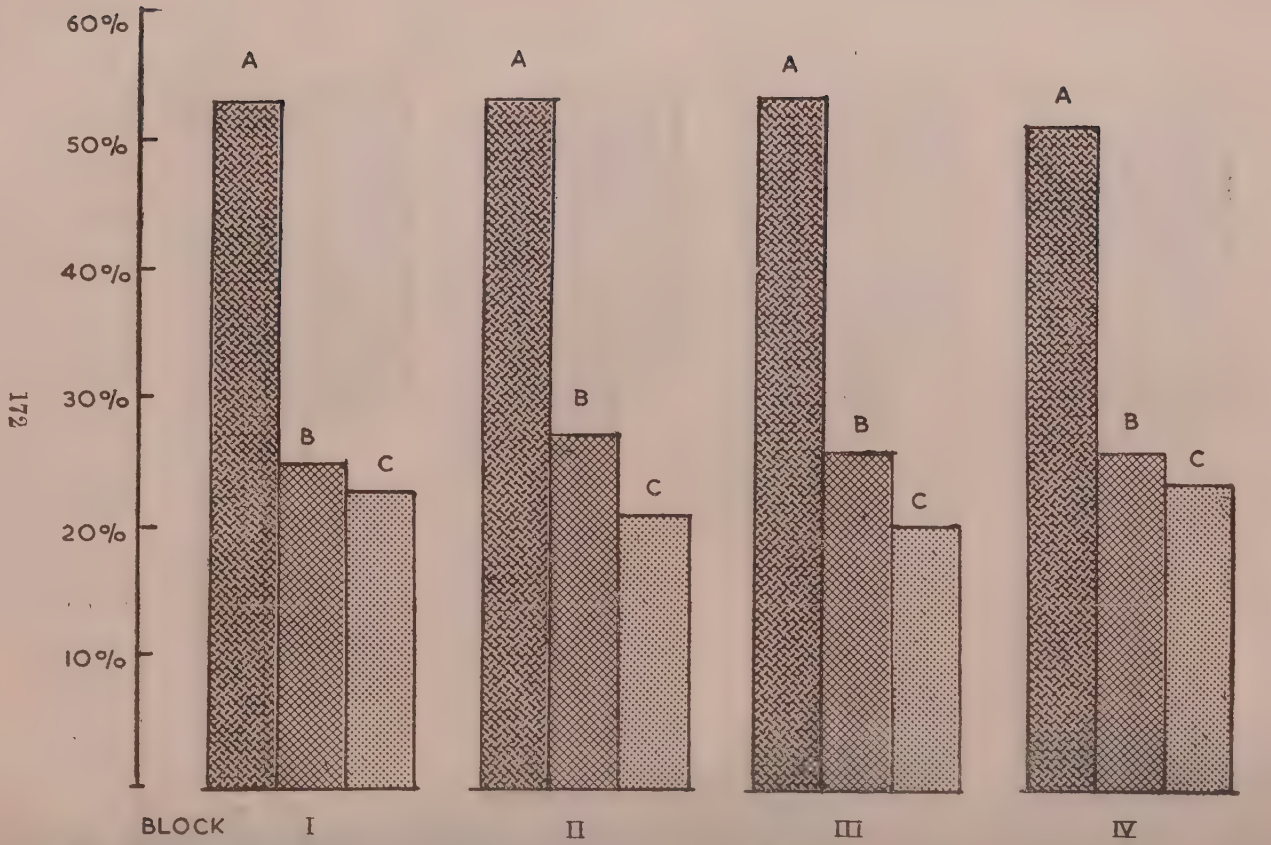

Fig. 2*a*.—Histogram showing the proportionate larval population of (A) *S. incertulas*, (B) *P. indicus* and (C) *S. inferens* in the stem-borer damaged paddy plants plotted on the observations of four years.

population of *P. indicus* is greater to *S. inferens*. So, it becomes evident that the size of the larval population of *P. indicus* and *S. inferens* are variable and the effect of the season has a influence over the size of the larval population of these two species.

Summary

Experiments were conducted to study the proportionate larval incidence of *S. incertulas*, *P. indicus* and *S. inferens* in the damaged paddy plants. The experiment was carried for four years. During the two seasons the larval population was observed to be *S. incertulas*>*S. inferens*>*P. indicus* and in other seasons the larval incidence was *S. incertulas*>*P. indicus*>*S. inferens*. But in aggregating the data of four seasons, the larval incidence was observed to be *S. incertulas*>*P. indicus*>*S. inferens*.

From the experiment it is concluded that the incidence of larval population of *S. incertulas* is always greater than *P. indicus* and *S. inferens* : but the magnitude of larval incidence between *P. indicus* and *S. inferens* is different in the different season. The overall ratio of the larval population on the basis of four years data between *S. incertulas* and *P. indicus* ; *S. incertulas* and *S. inferens* ; and *P. indicus* and *S. inferens* is 2 : 1 ; 2·5 : 1 ; 1·2 : 1 respectively.

Acknowledgement

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The authors thank Dr S. N. Banerjee, Entomologist, West Bengal for his constant help in this work.

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STUDIES ON THE BRANCHING PATTERN IN GROUNDNUT (*ARACHIS HYPOGAEA* LINN)

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(With 4 Text-Figures)

THERE is a wide range of variation in the varieties and forms of groundnut (*Arachis hypogaea*)cultivated in different countries. Classification of the varieties has been attempted by many workers mostly on the basis of different morphological characters. Vander Stok [1910] divided the cultivated types of Java into two main groups, viz., the long duration types and the short duration types. These groups, besides duration, differed in growth habit, branching, and size and colour of leaflets. The early duration group with bunchy habit was further divided into three sub-groups on the basis of pod and kernel characters. Badami [1930] distinguished seven groups based on their productivity. Differences in pod and kernel characters were the main basis for the classification of Chevalier [1933]. Hayes [1933], on the other hand, preferred the growth habit as the main basis for classifying groundnut varieties into bunch and runner groups and subdivided them into ten groups based on corolla colour, seed coat colour, hairiness, etc. Luzina [1935] distinguished three main groups comprising ten types in all, on the basis of duration, growth habit, etc. Clos [1939] classified the cultivated types in Argentina into fifteen distinct classes on the basis of habit of growth and pod and kernel characters. Bouffil [1947] argued that the carriage of the plant and dormancy of the seeds are the two characters of value in classification.

The morphology of the vegetative and reproductive branches was correctly described by Richter [1899]. Based on Richter's interpretation, Smith *et al.*, [1951] have enunciated a novel scheme of classification based on the branching pattern of the varieties. The nature of the branches produced, i.e. whether vegetative or reproductive, and their arrangement are taken as the criteria for classification. The ten types in their collection fall into two main groups, one including the spreading types and the other the bunch types. The latter group is further divided on the basis of the arrangement of the nodes into two categories. Bunting [1955] working with over 200 types representing the collection grown in Sudan classified them into alternatively branched and sequentially branched groups. John *et al.* [1954] after a detailed study of a very large world collection of varieties and forms of groundnut have put forth a scheme of classification. They have selected the growth habit,

seed coat colour, size of pods, and number of seeds per pod as the main characters of classificatory value and venation and constriction of the pod, nature of beak, etc. as minor characters to distinguish the different forms within a variety.

With a view to investigate whether branching pattern could be taken as a character of major classificatory value, a study of branching habit was undertaken by the present authors at the Agricultural Research Station, Tindivanam, Madras, on some of the important and distinct varieties and forms of groundnut. The following findings are of interest. The symbols n, n+1, n+2, n+3 as used by Smith *et al.* [1951] are adopted to indicate the main axis, the primary, secondary and tertiary branches (or the main axis, first, second and third order branches) respectively.

1. *Arachis hypogaea* var. *oleifera* forma *spanish*. The lateral buds on the lower portion of the main axis are vegetative (i.e., develop into vegetative branches) and higher up they are either vegetative or reproductive (i.e., develop into racemes). The primary branches (n+1 order) produce reproductive and vegetative branches irregularly, the first 3 or 4 nodes being consecutively reproductive (Fig. 1). The secondary branches (n+2 order) are rarely found and produce either vegetative or reproductive branches.

2. *Arachis hypogaea* var. *oleifera* forma *saloum*. All the nodes on the main stem are vegetative (Fig. 2). The primary branches (n+1 order) produce alternately two vegetative and two reproductive branches. The secondary branches (n+2 order) also produce either vegetative or reproductive branches. This alternation of vegetative and reproductive branches on the n+1 and n+2 order branches is not met with as a rule. The first one or two nodes on the primary and secondary branches always subtend vegetative branches.

3. *Arachis hypogaea* var. *oleifera* forma *native Tanganyika*. The branching pattern is similar to that in forma *saloum* (Fig. 3).

4. *Arachis hypogaea* var. *asiatica*. The branching pattern is similar to that in forma *saloum*, but branching is more intense with n+3 and n+4 order branches.

5. *Arachis hypogaea* var. *gigantea*. The nodes on the main stem are all vegetative. The primary and secondary (n+1 and n+2) branches, produce mostly reproductive branches. The nodes nearer the apex of the laterals are consecutively reproductive. The n+2 order reproductive branches are unusually elongated in this variety and very rarely become vegetative at the termity (Fig. 4).

6. *Arachis hypogaea* var. *nambyquarae*. The pattern is similar to that in forma *saloum* except that the reproductive and vegetative branches occur more irregularly on the laterals.

7. *Arachis hypogaea* var. *Rasteiro*. The pattern is similar to that of forma *saloum*.

The study has revealed that the branching in groundnut follows a certain pattern. The alternation of two reproductive branches and two vegetative branches in the prostrate or spreading types is noted but not so regularly as to justify this character

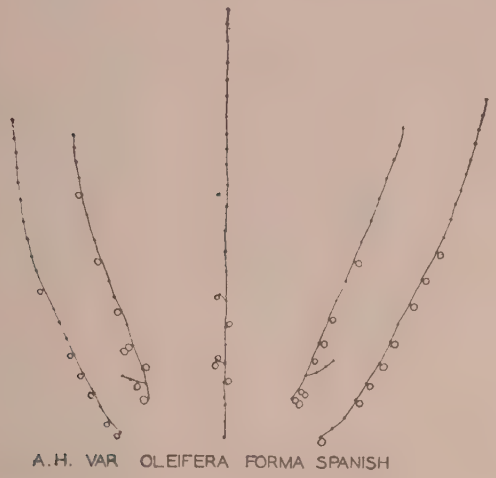

FIG. 1

Black dots—Vegetative nodes.
Circles—Reproductive nodes.

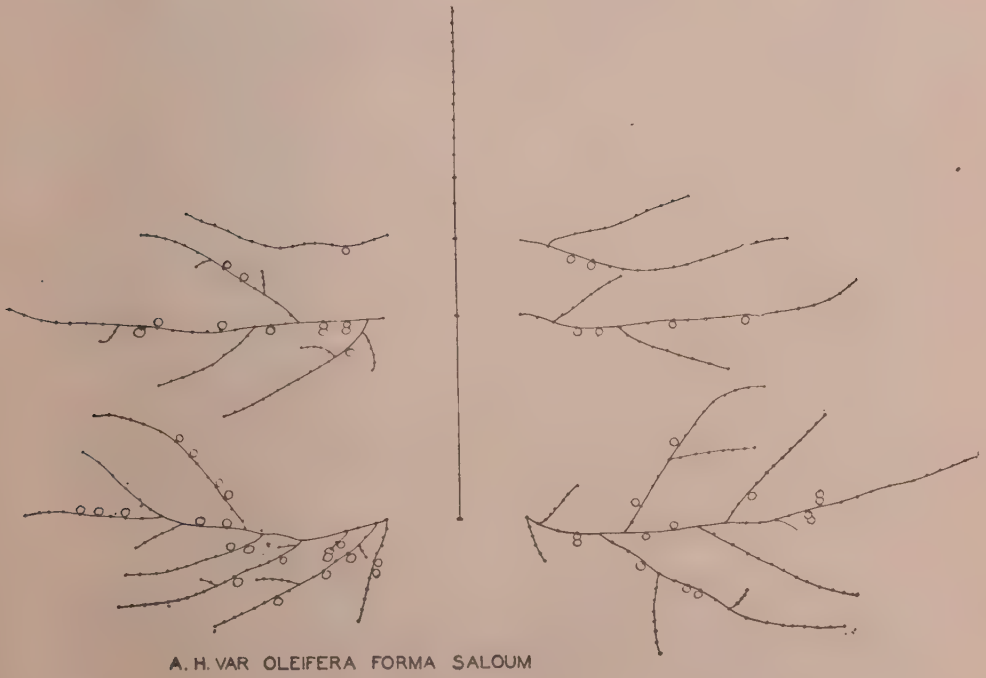

FIG. 2

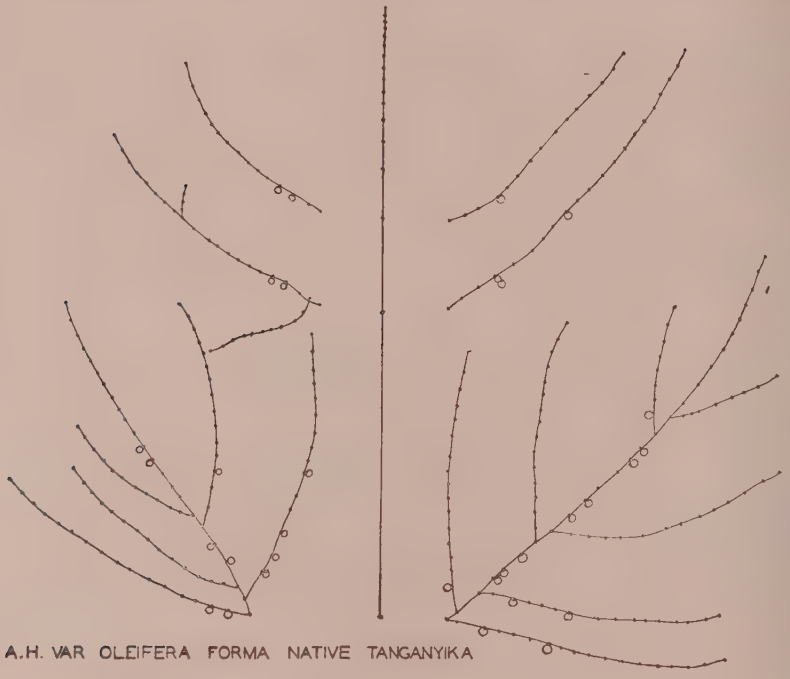

FIG. 3

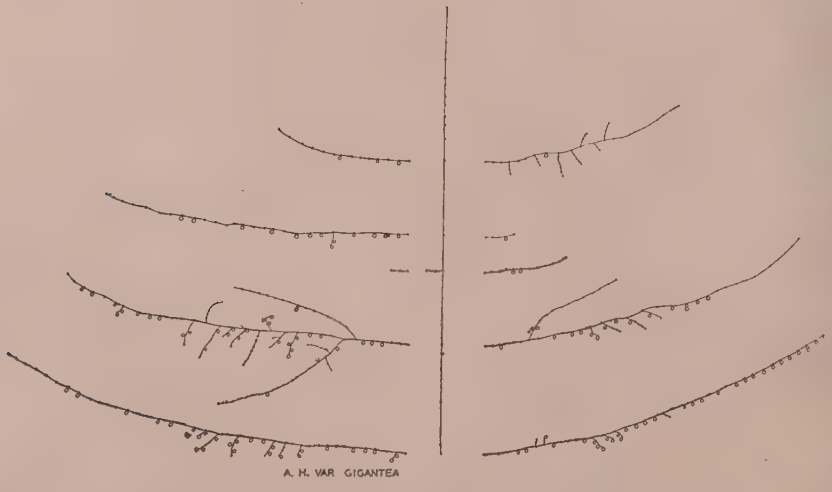

FIG. 4

Black dots—Vegetative nodes.
Circles—Reproductive nodes.

being taken as the sole basis for classification. Similar branching is noticed in var. *asiatica*, var. *Rasteiro* and in certain forms of var. *oleifera* also. These three varieties as discussed by John *et al.*, [1954] differ sufficiently to give them the status of distinct botanical varieties. Bringing them under a single group would only be artificial. In the var. *gigantea* which is a type extracted from a cross between a bunch and a spreading form, the branching is of a different pattern. The reproductive branch in this variety sometimes becomes vegetative at the tip and puts forth foliage. Therefore, the system of classification based on branching pattern may perhaps be dependable only in the case of a limited number of forms as enumerated by Smith. But when utilized in the classification of numerous varieties and forms this system does not appear to be reliable.

However, from the present study, it is established that the branching patterns of the bunch and spreading forms are different and are distinguishable. The system of branching in the two types is as follows :

Bunch type. Both vegetative and reproductive branches are produced from the main axis. The primaries (n+1 order) and secondaries (n+2 order) produce vegetative and reproductive branches irregularly. The first two nodes of the primary branches always subtend reproductive branches.

Spreading type. The main axis produces only vegetative branches. The lateral branches (both n+1 and n+2 orders) produce vegetative and reproductive branches in alternate pairs to a large extent. The first node on the laterals is always vegetative and the second, vegetative in most cases. The branching does not exceed n+4 order.

Previous workers [Stok 1910], Hayes [1933] and Clos [1939] have classified groundnut varieties based on growth habit. Smith *et al.* [1951] and Bunting [1955] preferred the branching pattern. Though the branching pattern shows close association with growth habit, still considering the variations observed in this character it seems reliable to adopt the growth habit as the basis of classification in preference to the branching pattern. Since there are other forms with growth habit like semi-spreading (intermediate between bunch and spreading) and erect [John and Seshadri 1956] possessing branching patterns similar to either the bunch or the spreading, the need for fixing the growth habit for purposes of classification of varieties and forms of the groundnut is confirmed. From the present studies it is further felt that even as a character of secondary value it would be more desirable to rely on other attributes like colour of leaflets, pod and kernel characters, etc. which are more stable and true to type.

Summary

The branching pattern was studied in different varieties and forms of groundnut. The branching pattern was clearly distinguishable in the bunch and spreading varieties and forms. The system of classification by Smith, *et al.*,

1951] and Bunting [1955] based on branching pattern was examined. It was found that it was more reliable to take the growth habit, as the basis of classification. Even as character of secondary value in classificatian, other characters like seed coat, colour, size and shape of pods, etc. are more reliable than the branching pattern.

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STUDIES ON THE VEGETATIVE PROPAGATION OF CASHEW (*ANACARDIUM OCCIDENTALE* L.)

I. AIR-LAYERING BY CINCTURING AND ETIOLATION OF SHOOTS

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(With 11 Text-Figures)

CASHEW (*Anacardium occidentale* L.) is almost universally raised by seed. The ready availability of the seeds coupled with the case with which they germinate and grow even under adverse soil and other conditions has perhaps been primarily responsible for the preference shown to this method of propagation over others. Cashew, regarded generally as a crop fit only for wastelands has not so far received the attention that it deserves on account of its capacity for earning foreign exchange for our country. The fact that there are no known varieties or types of cashew as in other commercially important fruit and nut crops may also be said to be partly responsible for the indifference displayed in the selection of the seed material. The extent of diversity met with in the several regions of the State in respect of such economic characters as yield, size, shape and contents of the nut due to seed propagation is, therefore, very wide, resulting in an assortment of the most unstandardised quality of produce received at the processing factories and leading eventually to serious reduction in prices. In plantations themselves, wide variations between trees in respect of the yield of nuts ranging from less than two pounds to as much as 40 lb. are of common occurrence [13]. The knowledge, that individual trees capable of yielding up to 200 lb. do exist in a number of tracts, serves only to emphasize the vast scope the crop offers for economic improvements.

The most potent means of ensuring uniformity in plantation material as well as increasing the plantation efficiency, therefore, appear to lie in the direction of making a comprehensive selection of desirable types and building up of their clonal strains by vegetative propagation methods. Work with horticultural crops has made clear the advantage to be gained by selected varieties propagated vegetatively.

Review of Literature

Except for the results of some preliminary trials reported from the Fruit Stations at Kodur (Cuddapah District) and Taliparamba (Malabar District), there appears to be no other record of any investigations on the vegetative propagation of the cashew. Dealing with the work at these Stations, Naik [11] has recorded that the cashew can be raised by several methods, as layering, inarching, side grafting, patch and shield budding and that of the several methods, layering and inarching appear to hold great promise for further investigations. Cuttings and raising of root suckers were also tried at Kodur but without success. The

results in budding operations were more encouraging, while side-grafting was distinctly promising though not as much as inarching or layering. The trials at Taliparamba are also reported to have resulted in rooting of 40 per cent of the layered shoots.

The method of layering by etiolation of shoots is one of the well known devices adopted in the vegetative propagation of plants. Gardner [3] obtained good results in apples by growing shoots inside black paper tubes and using this etiolated portion as the base of the cutting. He quotes Smith as having reported that *Clematis* which ordinarily roots only at the internode could be induced to root at the node if the stems had been previously wrapped with black paper tubes. Gardner [3] says that it is probable that in the absence of light, the initial stages of root primordia formation or perhaps the predisposition of certain cells to this development takes place before much differentiation of primary tissues has occurred and that some period of continuous darkness is necessary to permit further development of these primordia. He also cites the observation of Smith that etiolation causes a great increase in the rooting capacity of shoots, possibly due to the temporary accumulation of growth substances in the etiolated region due to some anatomical abnormality.

Attempts have been made to improve the efficiency of these treatments by wiring or ringing shoots whilst still attached to the parent plant. A swelling occurred immediately above the constriction and it is suggested that the extra food stored in the cutting assisted regeneration. Hunter [7] ringed shoots of citrus and found that the method is probably the most certain of success in the propagation of woody plants. Thakurta and Dutt [18] ringed shoots on young mango trees and smeared the ring with lanolin, containing three per cent indole acetic acid. The treated shoots severed and planted as cuttings rooted while no rooting occurred in untreated cuttings. San Pedro [16] working with avocado in Philippines found that roots grow strongly from the upper portion of the callus on cinctured shoots. Mohan Rao and Veeraraghavan [10] working with cinchona in the Anamalais (Madras), have found that among the various methods of vegetative propagation tested, the cincturing and etiolation method has given the best success.

The method of layering by cincturing may be said to be a slight modification of ' gooteeing' or marcottage. Recent advances in plant propagation technique have sought to devise measures to overcome the disadvantages associated with the earlier 'air-layering' methods. One of these is to employ plastic films as wrappers over the rooting medium and thereby obviate the cumbersome and costly methods employed hitherto, to keep the treated shoot continuously moist. These plastic wrappers due to their special properties of inertness, durability, toughness and impermeability, retain the moisture round the layers, at the same time allowing free passage of gases for respiration. Narasinga Rao [12] has reported on air-layering trials with polythene plastic film with 18 different fruit and other crops and concludes that the treatment at as many as five experimental centres in Madras State proved ineffective with all but litchi and crotons. Singh [17] working on litchi and jack has reported a high degree of success by the use of polythene wrapper along with an application of 'Rootone', a growth regulating substance.

The response to the treatment seems to be governed in a large measure by factors inherent in the plant tissues and the success of the operations is, therefore, apparently related to the condition of the plant and the climate at the time of the operation rather than on the calendar. Some species respond best when the parent plant is in active growth, while others react better when growth is slowing down and has ceased. Still others have so far failed to respond to any treatment. Yin and Liu[21] state that with many plants, the best results are obtained with cuttings collected at the end of the growing season or before the beginning of growth in early spring. Gardner [3] advocated taking apple root cuttings during the winter or early spring before growth begins, for at this time the roots are well supplied with stored food. Hitchcock and Zimmerman[6] working on *Ilex* species do not, however, seem to recognise any relationship between dormancy and rooting.

The age of the shoot selected for planting is an important factor in determining the success, and has also been a subject widely discussed. A certain period of the year is selected where the shoots are believed to be of the proper degree of maturity. In this manner, material referred to as soft wood, green wood, hardwood, hard, ripened wood are secured. Yin and Liu [21] found basal portion of the last season's growth best for propagating *Aleuritis* species by cuttings. Knight [8] found that the firm cutting which had ceased growth was much superior to actively growing shoots and suggested that this was probably due to high carbohydrate content. Starring, quoted by Garner [4] found similarly that a high carbohydrate content of soft-wood cuttings with low soluble nitrogen favoured rooting. He stated that firmness of stems may often be taken as an index of their fitness for cuttings in so far as the carbohydrate content is concerned. Stems low in carbohydrates are soft and flexible in contrast to those high in carbohydrates which are firm and stiff. Grace [5] and Farrar and Grace [1] working with Norway spruce found that cuttings taken from the lower part of the tree rooted better than those from the upper part and that laterals were consistently superior to terminals. This bears out Knight [8] who using soft-wood cuttings of Pyrus and Prunus found that non-elongating laterals rooted better than either laterals or terminals in active growth. Somewhat to the contrary, Pyke [15] found that in cacao, chupons (upright vigorous shoots) rooted better than fans (horizontal growing shoots). Tukey and Green[19] examined rose shoots and found a gradient of increasing moisture, ash and total nitrogen from base to tip and a gradient of decreasing starch content. Van der lek [20] found more root initials in the base of shoots than in the tips. Podluzhinii quoted by Garner [4] found that cuttings of olive from the lower third of the shoot rooted best, those from the middle next best and those from the terminal section scarcely at all. Hubert *et al.*, quoted by Pearce [14] found that basal parts of the shoots of *Vitex agnus* root more readily than apical cuttings.

Material and Methods

Adult bearing trees of known performance in cashew plantations in the neighbourhood of the Cashew Research Station, were pressed into service for the trials which were initiated in September, 1953. To begin with, about a year old shoots that did not put forth new growths and ranging in stem diameter from 0·8 cm. to 1·4 cm. were chosen for the trial. Thirty shoots were operated each month.

The operation consisted in removing a strip of bark about $\frac{1}{8}$ inch to $\frac{1}{4}$ inch wide round the shoot at the point at which roots are required and winding over the treated portion a strand of twine to prevent the exposed ends from healing over. The shoot is etiolated by covering with moist moss, and wrapped with a piece of polythene ('Alkathene') film (150 gauge), the ends of which were secured with twine (Fig. 1). The treated shoots were not watered at any subsequent stage.

The trial was repeated at monthly intervals, thereafter adopting the procedure detailed above.

As an extension of the above trial, a series of treatments employing current season's shoots was taken up from January, 1954. Shoots ranging in thickness from 0·4 to 0·8 cm. of the following six categories were cinctured in January, 1954, the method of operation being the same as with the one year old shoots :

1. Shoots in flush (one to two weeks old)
2. Shoots which had not flowered (three to 12 weeks old)
3. Shoots in which flowering had just commenced
4. Shoots with panicles developed to half their size
5. Shoots with fully developed panicles
6. Shoots in which fruit development was in progress

In the months of February and March, 1954 shoots of only four categories could be operated as flowering shoots were not available in adequate numbers, while subsequently only the first two classes of shoots could be worked.

The material presented in this paper refers to a 12-month cycle of operations with one year old shoots and eight months with the current season's shoots.

In the initial stages of the trial, periodical examinations at fortnightly intervals of five shoots of each batch showed that callus formation was followed by the appearance of root primordia and the emergence of roots, some of which pierced the polythene wrapper. Some roots could also be felt and seen through the transparent film. The wrapper round each shoot was unwound and the production of five or more well formed roots, about $\frac{1}{2}$ inch or more in length was considered as the stage fit for initiation of the operations for the severance of the shoot from the parent. In order to lessen the shock of sudden severance, each rooted shoot was given a preliminary penetrating half way through the stem about an inch below the region of root emergence, 15-20 days before the anticipated date of separation. As the rooting response varied with each monthly batch according to the seasonal features, no definite period could be fixed for these stages of severance. The appearance of the root tips out of the transparent wrapper served as a rough guide. A second cut depending the first one was given a week later, followed by the third and final cut separating the shoot 10 days later. In certain months when the rooting was quick and profuse, the second cut separated the shoot from the parent. In the case of current season's shoots, it was found possible to effect severance without the preliminary cuts. The rooted shoot was transferred to a container made out of

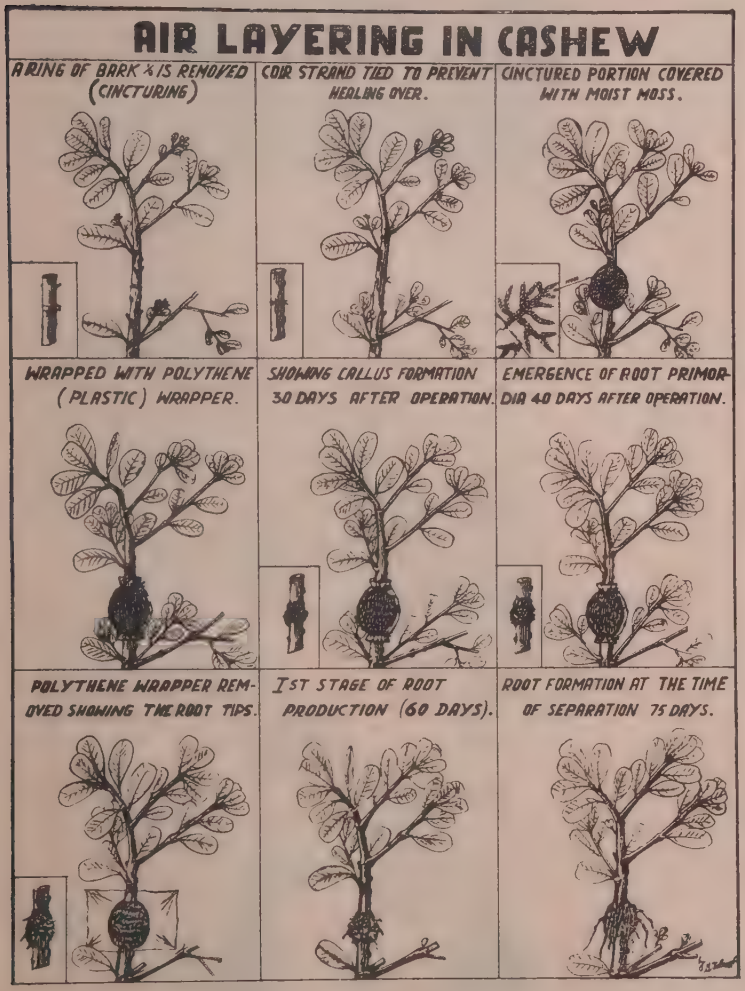

Fig. 1.—Several stages of airlayering

Fig. 2(a).—Airlayering (current season's shoot)

Fig. 2(b).—Separated from the parent tree

hill grass about nine inches long with a diameter of about five inches at the top and about three to four inches at the bottom (Fig. 6) filled with a mixture of two parts of red earth and one part each of leaf mould, ash and cattle manure. The plants were watered and kept in shallow trenches under shade. Most of the potted plants exhibited an initial withering but put forth a crop of fresh shoots later on.

The plants obtained thus from December, 1953 were maintained in the nursery, as the season was not favourable for planting. With the break of the monsoon in June, 1954, 54 layers raised out of one year old shoots and 30 from current season's shoots were planted out in the field. The planting was continued in the subsequent months also, until eventually 131 clonal progenies of both the categories were planted out in the field in pits $1\frac{1}{2}$ ft. $\times$ $1\frac{1}{2}$ ft. $\times$ $1\frac{1}{2}$ ft. No watering was done either during or after planting.

In order to study the effects of setting out clonal progenies directly in the field after separation without any preliminary nursing, 50 rooted plants consisting of 38 raised from one year old shoots and 12 from current season's shoots were planted out directly after separation in the field in June, 1954, without any prior nursing.

The clonal material was distributed in four different sections of the Station to represent soils ranging from deep red loams to those with shallow rocky substrata (Fig. 7) as well as under exposed and sheltered situations, and also alongside a comparable set of seedling progenies raised at the same time and in almost similar situations.

The cost of production of rooted plants was worked out. In order to see if the costs could be reduced further by employing cheaper wrapping material at least during the monsoon months, separate trials with banana sheath as a wrapper were also conducted.

Results

The results of the observations are presented separately for layers raised out of one year old shoots and current season's shoots.

The following is a summary of the observations regarding the appearance of callus, root primordia and roots in each of the months, and the figures represent the means for 12 months in the case of one year old shoots and eight months in the current season's shoots:

(1) In the case of one year old shoots, it takes 32 days for callus formation, 45 days for appearance of root primorida, 63 days for root formation and 83 days for final separation, while in the current season's shoots it is 29, 55, 66 and 82 days respectively showing thereby that the period between the operation and separation of rooted plants is the same regardless of the age of the shoot.

(2) The period between the several stages of development varies in each month, resulting in the time of separation extending from 57 days in January to 103 days in June in the case of one year old shoots, and from 67 to 105 days with current season's shoots.

(3) The operations carried out in the months of November, December and January have generally produced the rooted plants earliest which is also borne out with the current shoots, while June and July operations seem to be slowest.

The early rooting seems to be correlated to the period when the tree is in its height of activity while during the period of the cessation of growth as in June and July, the rooting tends to be slow.

The success with each batch of shoots in each of the several months of the operation judged by the percentage of root production and number of plants ultimately separated is represented in Table I.

TABLE I

Cashew Air-layering by cincturing (showing the percentage of success with (a) one year old shoots)

Months	No. cinctured	No. rooted	No. separated successfully	Percentage of rooting	Percentage of successful separation	Remarks on the condition of the parent tree
September	30	25	25	83·3	83·3	Pre-flush stage
October	30	29	29	96·6	96·6	Blossom appear
November	30	30	30	100·0	100·0	In bloom
December	30	22	22	73·3	73·3	In bloom
January	30	25	25	83·3	83·3	In bloom. Fruit set
February	30	28	28	93·3	93·3	Fruits in various stages of development
March	30	28	28	93·3	93·3	
April	30	28	24	93·3	80·0	Flowering complete. Fruit in development
May	30	20	16	66·6	53·3	Harvest completed
June	30	5	5	16·6	16·6	Dormant
July	30	13	13	43·3	43·3	Dormant
August	30	22	22	73·3	73·3	Pre-flush stage
Mean	30	23	22·3	76·4	74·1	
			(b) Current season's shoots			
January	60	44	44	73	73	Fruit set
February	40	23	23	58	58	Fruits in various stages of development
March	40	17	17	42·5	42·5	
April	20	12	12	60	45	Flowering complete
May	20	17	17	85	85	Fruit in development. Harvest completed
June	10	5	5	50	50	Dormant
July	10	5	5	50	50	Dormant
August	10	6	6	60	60	Pre-flush stage
Mean	26·3	16·1	15·8	59·8	57·9	

Fig. 3.—Rooting-(current season's shoot)

Fig. 5.—Rooting-one year old shoot

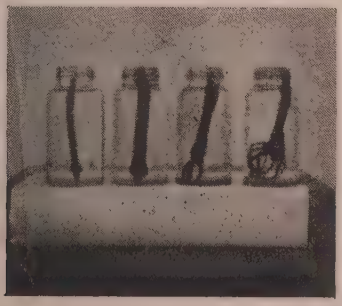

Fig. 4.—Eallus formation and rooting

It is observed from Table that :

(1) the percentage of rooting varies from 16·6 in June to 100 per cent in November with a mean of 76·4 in the case of one year old shoots while with the current shoots, the mean percentage works out to 59·8 with a range between 42·5 and 85 per cent,

(2) except occasionally, it is possible to separate the rooted plants successfully without casualties between rooting and separation,

(3) except during June and July, the rest of the year appears suitable to this method of propagation, the operations between August and April in particular yielding the best results. With the current shoots, however, it is seen that the results are more uniform,

(4) the maximum success is achieved when the parent tree is both in flush and flower, and the favourable response to the treatment commences with the pre-flush period, starting from August. June and July, the rainy months of the year, when the trees are dormant, appear less suitable and

(5) between one year old and current season's shoots, there are indications of higher success with the former.

The corresponding data with current season's shoots show that :

(*i*) Cincturing of current season's shoots is also a method holding promise with all the six categories of shoots under trial, including those in flower and fruit,

(*ii*) with the non-flowering shoots which are available for operation all through the year, the success in rooting has not fallen below 40 per cent at any stage while a maximum of 90 per cent has been recorded in January and May and

(*iii*) the data on percentage of survival at the end of a month do not indicate any spectacular differences, between the one year old and current season's shoots.

Root growth. Observations were also recorded on the nature and extent of root growth in each class of shoot. Following the callus formation, a thick cluster of root primordia with pustule like eruptions make their appearance giving rise to roots, red in colour with a pinkish white pointed apex, some piercing their way out of the plastic film wrapper. The roots were also examined at the time of severance from the parent and measurements were recorded of the length of individual roots from their base to the tip, and circumference at the point of emergence.

The following is a summary of the observations :

The thickness of each root ranges from 0·9 to 1·6 cm. at the base, (ii) the difference between the roots produced by one year old shoots and the current shoots is not very appreciable and (iii) about 11 roots are produced by each one year old shoot while the corresponding number for current shoots is five.

It was also observed that the main roots emerged from the upper edge of the ring bark below which secondary roots smaller in size were also seen to push out. The different stages of the progress of the root production are represented in Figs. 3 to 5. The direction of the root growth was generally downwards or towards the base of the tree, except in a few cases, where due probably to the disturbance caused during the periodical observations, the roots turned upwards.

It was also observed in the course of the investigations that the separated plants could be retained in the hill grass containers only for a certain period and that prolonged maintenance in these containers resulted in progressive casualties which were particularly severe during the dry weather period from November to May.

For setting out clonal progenies directly after separation in the field in the month of June without prior nursing, the layering operations done any time after February may suit the purpose.

Planting. A study of the progress of 84 clonal progenies consisting of 54 raised from one year old shoots and 30 from current season's shoots, four months after planting, indicated that the progress of layers raised from one year old shoots may be considered as satisfactory regardless of the fact that they are nursed or directly planted. With regard to layers raised from current season's shoots, further observations seem necessary to determine the effects of direct planting. Fig. 7 shows one of the clonal progenies (one year old shoot) growing satisfactorily in the midst of rocks. Figs. 8 to 10 show the progress of another, soon after planting in June, 1954, after about four months, in October, 1954 and again when 18 months old, in December, 1955 when the plant had flowered. Fig. 11 shows a clonal progeny raised out of current shoots, five months after planting.

In order to observe the reactions with subsequent plantings in the months of August, September and October which are relatively less rainy, 47 progenies (7 'one year old' and 40 'current') were planted out, of which only 13 survived, indicating that under the rainfed conditions in the West Coast, it may be preferable to restrict the planting operations to June and July.

Economics. With a view to study the economics by this method of vegetative propagation, an attempt was made to work out the cost of production of clonal material primarily to see if it would be possible to apply this method for commercial exploitation. The cost, at an average success of 76 per cent works out to Re. 0/2/8 per plant as detailed in Table II.

TABLE II

Cost of production of layers

	Rs.	A.	P.
Cost of 1/6 lb. of Alkathene linear film (150 gauge) at Rs. 7-12-0 per lb. for layering 100 shoots	1	4	8
2½ lb. of moss at Rs. 5-12-0 for 25 lb.	0	9	3
One roll of twine	0	4	0
Grass containers at Re. 0-0-6 (76 grass containers for potting 76 plants expected out of 100 layers made)	2	6	0
Labour for cincturing	2	8	0
„ „ primary cuts	0	5	0
„ „ separation	0	5	0
„ „ potting	0	10	0
Subsequent watering of plants for one month at ½ boy per irrigation	1	4	0
Cost of scion shoots	3	2	0
TOTAL	12	9	11
The mean percentage of success is 76			
Cost of 76 plants	12	10	0
Cost per plant	0	2	8

Fig. 6.—Layers transferred to grass containers

Fig. 7.—A layer planted in the midst of rocks

Fig. 8.—Layer from one year old shoot planted out in June, 1954

Fig. 9.—The same layer after four months

Fig. 10.—The same layer when 18 months old with flowers on

Fig. 11.—A layer from current season's shoot five months after planting

As a step towards economising the costs further, banana sheath was tried as a substitute for the polythene film but was found unsuitable, as it could not retain the moisture during the occasional spells of dry weather between the showers.

Discussion

Vegetative propagation of any plant with the object of large scale commercial production of nursery stock demands a cheap, certain and quick method. This is particularly true of cashew, vast areas under which are found only in wastelands and remote hilly areas. The scant attention that the culture of the crop receives at the hands of the growers, is a fact to be reckoned with, particularly in the context of any suggestion for its improvement through "pedigree" plant material. Any recommendation towards this end, therefore, may have no value unless it is practicable on a commercial scale.

Viewed against the above background, it is gratifying to note that the trials on the production of rooted plants through air-layering by cincturing of shoots has yielded encouraging results. When the details pertaining to this method are standardised, it is likely to rank as one of the best among the several methods of vegetative propagation that are possible with the species. The method is relatively simple, requires no particular skill and is, therefore, suitable for adoption in the large-scale multiplication of the crop for commercial exploitation. However, a study of the behaviour of these clonal progenies on their own roots, as orchard entities, in comparison to unworked seedlings and those raised by budding and grafting methods involving several scionic combinations, is necessary to determine ultimately the relative merits and demerits of the several methods.

With the exception of June and July, the rooting response may be said to be good all through the year, with the period between August and April being particularly congenial. The unsuitability of the two months of June and July can perhaps be explained by the fact that the tree is absolutely inactive during this period, which does not seem to be conducive to root production, while the pre-flush period in August marks the beginning of the successful phase. The intensity of rooting increases as the plant enters the active growth phase. This active phase which starts from August may be said to last till the end of April. Throughout this period, it may be observed, the success in rooting as been fairly uniform, never less than 73 per cent and sometimes even as high as 100 per cent.

These findings are in agreement with those of Mohan Rao and Veeraraghavan [10] whose work deals mainly with current season's shoots arising out of coppiced cinchona plants. The prolonged success even during November and December when the growth activity in the cashew is on the increase, is again a result which is concurrent with the findings of Gardner [3], Yin and Liu [21] who advocate taking cuttings in early spring. The inactivity of the tree in June and July when the shoots were characteristically shy-rooting indicates a definite negative correlation between dormancy and root production. The gradual increase in the rooting percentage with the increasing activity of the plant and an equally evident drop in the success as the plant enters the dormant phase from May onwards, seems to strengthen this relationship.

The physiological aspect of this phenomenon has been a subject on which diverse and conflicting views have been expressed and the plant responses have been variously attributed to the accumulation of food material or of a hypothetical hormone. In cashew, the higher success in one year old shoots as compared to current shoots and low success during the period of high rainfall in June and July, when due to the overcast sky and high water content, the growth activity is the least suggests that as reported by several workers, the accumulation of stored food material, possibly carbohydrates, as well as growth activity are responsible for rooting.

The favourable response obtained with the batches after October and particularly after February is an advantageous feature, in that the separated plants become available for setting out in the rainy months of June and July. On the other hand, the relatively low percentage of success in the months of June and July is not really of any serious consequence, because even if successful, the clonal progenies raised during this period are available for planting out only after September which under West Coast conditions, appears rather late. The renewed success from the month of August dispels any doubt regarding the possibility of the prolongation of the unsuccessful period beyond two months.

A parallel series of investigations may, however, be necessary to study the responses under the East Coast conditions.

The extension of these trials to devise suitable measures to keep the plants alive in the nursery for longer periods after separation, or in other words, to keep down the rate of casualties between separation and planting seems necessary in order to aim at an all-the-year-round production of clones both for local distribution and for long distance transport, to cater to the needs of the several tracts with diverse climatic conditions.

The study on the nature and extent of roots produced by each shoot indicates that the older shoots tend to produce a larger number of roots. One might be inclined to prefer a plant with a larger root system for successful establishment, and on this score, the one year old plants are to be considered superior. A larger number of roots may also help better anchorage, and, therefore, desirable. However, the successful establishment of 14 out of 18 clonal progenies of current season's shoots shows that a fewer number of roots in this class of shoots may not really be considered a handicap. Moreover, the ultimate structure and development of the root system as the trees age, may not be such as would enable a distinction regarding their origin from one class of shoot or the other, because by then, the slight differences discernible in the earlier stages may be expected to even out. The performance of the clonal progenies of several categories which have now been set out at the Cashew Research Station, Mangalore, alongside a comparable set of seedlings and under different environmental conditions may be expected to provide interesting material for study in due course.

The success of these layering operations in cashew may be said to be in a large measure due to the plastic polythene ('Alkathene') film, the utility of which, as evidenced by the results, is beyond dispute. The trials were for a large part conducted

in the rainless period, when in the ordinary course, hand watering of the operated shoots would have been the normal procedure and even that with uncertain prospects of success. The use of the polythene film not only eliminates this cumbersome and costly procedure, but also assures the maintenance of a continuously moist condition on the treated shoot, which is one of the foremost conditions for success. The use of the plastic film may be necessary, even during the monsoons in July and August, at least in the West Coast of India, when any other wrapper may not stand the severity of the rains more effectively. Banana sheath wrappers, which were tried during the monsoon season, were unable to retain the moist condition during a short spell of dry weather between the showers after July. The saving of labour for continuous watering may be considered as the greatest advantage in the use of these wrappers, whose utility is enhanced by the fact that several kinds and gauges of the film are available readily in the market to suit a diversity of crops and conditions.

Summary

1. The need for devising measures for propagating cashew by vegetative means has been stressed.

2. The available literature on cashew and layering by cincturing and allied subjects has been cited.

3. The method of air-layering by cincturing and etiolation of shoots employing plastic film wrappers has been described.

4. It has been found possible to obtain clonal progenies from one year old as well as current season's shoots in 83 days. Current season's shoots of six categories including those in flush, flower and fruit were also found to respond to the treatment.

5. Except June and July the rest of the months in the year were suitable for undertaking propagation with the operations between August and April, in particular, being the most successful. A maximum success of 100 per cent was achieved in November operations.

6. One year old shoots appeared to have a tendency to produce larger number of roots than current season's shoots.

7. It was found possible to set out clonal progenies (of one year old shoots) directly after separation from the parent in the months of June and July while during the other months, a period of nursing appeared necessary before final planting.

8. Planting clonal progenies after August appeared undesirable under West Coast conditions.

9. The cost of production of clonal progenies worked out to Re. 0-2-8 per plant.

10. Polythene film as a wrapper was found very efficacious and economical as compared to banana sheath which was unsuitable.

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GROWTH AND QUALITY OF CIGAR TOBACCO LEAF AS INFLUENCED BY ITS POSITION ON THE STALK*

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SEVERAL workers have investigated the variations in the growth and structure [Berthold, 1929, 1931 ; Avery, 1934 (Cigar tobacco) ; Wolf *et al.*, 1937 (flue-cured tobacco) ; Wolf *et al.*, 1944 and Wolf, 1947 (Oriental tobacco)] ; chemical composition [Hanmer *et al.*, 1940 (Cigar tobacco) ; Darkis *et al.*, 1936 ; Askew *et al.*, 1947 (flue-cured tobacco) ; and Garner *et al.*, 1934 (Maryland tobacco)], and quality of tobacco leaf as influenced by its position on the stalk. The necessity of similar studies on cigar tobacco plant as grown in South India was felt in view of the differences in soil and climatic factors and in the methods of curing and fermentation adopted in South India. The information obtained is expected to help in formulating sound grading schedules.

Material and Methods

Cigar tobacco seedlings (*N. tabacum* variety *Vellaivazhai*) of eight weeks growth and having three leaves and growing point were selected and transplanted on ridges at a spacing of $2\frac{1}{2}$ ft. between rows and 2 ft. between plants. To avoid incidence of gaps the seedlings were transplanted in duplicate, one of which was removed after establishment (12 days after transplanting). The crop received a basal dose of farmyard manure at the rate of 10 short tons and sulphate of ammonia at 50 lb. nitrogen per acre. Farmyard manure was broadcast a fortnight before transplanting and the sulphate of ammonia at the time of transplanting. The crop was raised under well irrigation and received the usual cultural operations of weeding (weeding included a shallow hoeing) and *mummatti digging* (deep hoeing and earthing up) 3 and 6 weeks after transplanting respectively.

For purposes of observations and sampling the field was laid out in 4 replications. In order to keep track of the morphological position of the leaves, weekly observations on the number of bottom leaves that had dried and died from each plant were taken. During the 8 weeks of growth in the nursery the seedlings lost 4 leaves excluding the two cotyledons. The transplanted seedlings had 3 leaves and growing point. From transplanting to topping (10 weeks after transplanting) the plants lost 10 leaves from bottom upwards. Thus 14 leaves were lost on the

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whole plant and leaves 15 to 28 were left on the plant at the time of topping (14 leaf topping). For the sake of convenience the 14 leaves on the plant have been numbered 1 to 14 from the bottom to top.

The following observations were taken to study the variations in the growth and quality of the leaf :

Area of leaves ;

Weight of green and cured leaves ;

Percentage of good grade leaves by number and weight ;

Moisture content of cured leaves ;

Leaf burn and cigar burn tests.

For measurement of area of leaves 16 plants were selected at random (4 plants in each replication). Measurements were started two weeks after transplanting and continued at weekly intervals thereafter till the time of harvest (13 weeks after transplanting). The area of each leaf was obtained by measuring the length and breadth of the leaf and then calculated from the regression equations worked out by the authors [Tejwani *et al.*, 1957].

Weight of green and cured leaves was determined in quadruplicate. Green weight of leaves was determined at the time of harvest. Ten plants were selected at random in each of the four replications, the green mature leaves were primed according to their position on the stalk and weighed. The weight of cured leaves was recorded at the time of stripping (i.e. the time of removing the leaves from the stalk after fermentation was complete) on another set of 40 plants selected at random in equal number from all the four replications. The moisture content of cured leaves was determined by drying the stripped leaves in a steam oven at 95°C.

The grading of leaves in accordance with the local system was done at the time of stripping on 40 plants selected at random in equal numbers from the four replications. Big and medium sized, undamaged leaves which would serve as binders were classed as good grade, while small and damaged leaves were classed as *Kruz* grade (i.e. inferior grade). The number and weight of leaves of each grade were recorded and their relative percentages worked out.

The bottom-most two leaves usually dry up completely by the time the plant is harvested and they are very thin, papery and brittle. It was thought advantageous to investigate whether these two leaves can be primed before they dried up so as to increase the yield. They were, therefore, left on the plant in the first year and were primed 10 days after topping and cured separately in the second year of the study.

The good grade leaves of any particular leaf position obtained from all the four replications were mixed to prepare a composite sample. Two sub samples of 10 and 20 leaves each were taken at random from this composite sample for leaf burn and cigar burn tests respectively. The leaves for leaf burn were brought to

condition and divided into three parts, viz. tip, middle and bottom, on either side of the midrib. Leaf burn tests were made on all the six portions of the leaf using a leaf burn apparatus similar to the one used by Johnson [1941] and the average of 60 determinations was taken to represent the leaf burn of a particular leaf position [Johnson, 1941].

Eight cigars were made out of the 20 leaves collected for cigar burn tests. Each cigar was $4\frac{1}{2}$ in. long and weighed about 6 grams. Before conducting the burn tests, the leaf portions and cigars were brought to a uniform and optimum moisture condition for burning by keeping them for 3 days over a saturated solution of magnesium nitrate in a desiccator.

The quality of the cigars was evaluated by considering the following properties associated with cigar burn :

(a) The character of ash—its colour, size and firmness (coherence).
(b) The nature of burn fire holding capacity (time), evenness, carbon zone (margin) and speed (rate), and
(c) Smoking characteristics—taste, aroma and strength.

Each property was allotted certain number of points as shown in Table I. The average score of 8 cigars was taken to represent the burning quality of the leaf.

TABLE I

The scoring system used in cigar burn tests showing the characters observed and the distribution of points

Grades of Characters	Ash										
	Colour					Size			Coherence		
	White	Whitish grey	Grey	Dark grey	Black	Enlarged	Unchanged	Reduced	Firm	Medium	Flaky
Points	5	4	3	2	1	3	2	1	3	2	1

Grades of Characters	Burn														
	Time					Evenness			Margin			Rate			
	5 (+) minutes	4 minutes	3 minutes	2 minutes	1 minute	Even	Medium	Uneven	Narrow	Medium	Broad	Medium	Fast	Slow	
Points	5	4	3	2	1	3	2	1	3	2	1	3	2	1	

Grades of Characters	Smoking Quality										
	Taste				Aroma			Strength			
	Smooth and soft	Medium	Sharp and rough	Rough and biting	Pleasant	Neutral	Unpleasant	Mild	Medium	Strong	Total Cigar Score
Points	7	5	3	1	5	3	1	3	2	1	40

Results and Discussion

Area of leaves

In Table II are summarised (*a*) the leaf area from emergence to harvest at weekly intervals of each of the 14 leaves ultimately harvested and (*b*) the area of the leaf at three growth phases of the plant* as percentage of the final area of the leaf.

The above data indicate that the leaves at positions 1 to 6 emerged during the transitional phase while the remaining leaves at positions 7 to 14 emerged half way through the active phase (8 weeks after transplanting) of growth. Leaves at positions 1 to 6 completed their growth by the time the plant was ready for topping (10 weeks after transplanting), leaves at positions 7 to 9 increased in area by 15 to 25 per cent after topping and leaves at positions 10 to 14 increased in area by 34 to 65 per cent after topping. The magnitude of growth after topping increased progressively from bottom to top. These data clearly demonstrate that after topping the growth is confined to the leaves in the upper half of the plant. These observations are in conformity with the findings of Berthold [1931] and Avery [1934] for cigar tobacco and Wolf *et al.* [1937] for flue-cured tobacco, who observed that topping had little or no effect on the leaves on the lower half of the stalk which were mature at the time of topping but several of the upper-most leaves which were only partially developed at that time were stimulated to greater growth. The statistical analysis of the data revealed that leaves at positions 7 to 12 were the best leaves as judged by the leaf size.

* Four growth phases of the cigar tobacco plant [Tejwani *et al.*, 1957] : (i) establishment phase (up to 3 weeks after transplanting), (ii) transplantational phase (4th to 6th weeks after transplanting), (iii) active phase (7th to 10th weeks after transplanting) and (iv) maturation phase (11th to 13th weeks after transplanting).

TABLE II

Cigar tobacco leaf area (in inches) according to its position on the stalk (mean of 2 years' observations)

Leaf position from bottom	Growth phase and weeks after transplanting									Area of each leaf at the three phases of growth of the plant expressed as percentage of final area of the leaf		
	Transitional phase of growth (weeding to *mummatti digging*)		Active phase of growth (*mummatti digging* to topping)				Maturation phase of growth (topping to harvesting)			Transitional phase of growth	Active phase of growth	Maturation phase of growth
	5	6	7	8	9	10	11	12	13			
1	6·0	38·4	95·1	136·0	154·3	161·0	161·8	161·8	161·8	23·73	75·77	0·05
2	4·4	24·1	90·6	148·6	177·7	185·2	191·1	191·5	191·5	12·58	84·13	3·29
3		13·2	64·0	139·7	180·5	197·3	201·3	202·5	202·7	6·51	90·82	2·67
4		6·4	43·0	126·3	183·4	200·1	213·7	215·6	215·2	2·97	92·75	4·29
5		5·5	25·5	107·2	177·8	208·6	218·3	223·1	225·4	2·44	90·11	7·45
6		4·0	14·7	80·5	162·1	207·9	219·0	225·4	228·4	1·75	89·28	8·97
7			7·9	59·9	151·9	213·6	237·1	245·2	250·8		85·17	14·83
8			7·4	44·0	124·5	203·0	229·7	241·4	247·1		82·12	17·88
9			5·6	29·2	99·9	186·0	222·2	238·0	246·4		75·49	24·51
10				19·6	78·1	168·9	217·6	241·6	254·5		66·37	33·63
11				11·2	55·5	138·8	195·8	221·2	240·1		57·81	42·19
12				9·5	38·0	118·4	186·4	214·3	235·4		50·30	49·70
13				6·1	26·5	91·7	158·0	189·7	210·8		43·48	56·52
14				5·4	18·6	65·1	135·1	165·3	183·4		35·50	64·50
S.E. per cent									14·30			
C.D. at 5 per cent									15·60			

The length : breadth ratio from emergence to harvest at weekly intervals for each of the 14 leaves ultimately harvested are given in Table III.

TABLE III

Length : breadth ratio of cigar tobacco leaf according to its position on the stalk (mean of 2 years' observations)

Leaf position from bottom	Growth phase and weeks after transplanting								
	Transitional phase of growth (weeding to *mummatti digging*)		Active phase of growth (*m ummatti digging* to topping)				Maturation phase of growth (topping to harvesting)		
1	3·40	2·30	1·94	1·97	1·98	1·97	1·92	1·92	1·92
2	3·65	2·66	2·04	1·95	2·01	2·02	2·02	2·01	2·01
3		3·25	2·41	2·08	2·07	2·10	2·07	2·08	2·08
4		5·01	2·87	2·22	2·10	2·14	2·14	2·12	2·12
5		4·38	3·25	2·40	2·17	2·19	2·22	2·18	2·19
6		4·33	3·82	2·73	2·32	2·27	2·30	2·28	2·27
7			4·12	3·12	2·40	2·29	2·30	2·33	2·29
8			4·72	3·29	2·67	2·38	2·43	2·35	2·35
9			4·55	3·76	2·96	2·46	2·45	2·45	2·42
10				4·15	3·49	2·64	2·59	2·54	2·55
11				4·84	3·91	2·96	2·76	2·70	2·64
12				5·43	4·52	3·22	2·87	2·77	2·72
13				5·99	4·78	3·56	3·06	2·87	2·82
14				6·44	5·69	4·09	3·11	3·07	3·06

The data indicate that for any leaf, the magnitude of the ratio which was the highest at the time of emergence decreased as the leaf grew and in about 4 weeks reached a more or less constant value. This indicates that the leaf, as it emerged, was very narrow and that its breadth increased more rapidly than the length for the first four weeks after which the leaf grew at the same rate in both the directions. The magnitude of the ratio rose from bottom to top of the plant indicating that the breadthwise development of leaves was reduced progressively in the higher positions on the plant and, consequently, leaves tended to be longer higher up the plant.

Weight of green and cured leaves

TABLE IV

Weight of green and cured leaves and percentage moisture content of cured cigar tobacco leaf according to its position on the stalk (mean of 2 years' observations)

Leaf position from bottom	Weight of green leaf (gm.)	Weight of cured leaf (gm.)	Per cent moistu re content of cured leaf (1953-54)	Dry matter (m.gm.) per sq. inch (calculated values)
1	*	3·97	23·65	18·7
2	*	4·96	25·56	19·3
3	*	5·18	26·67	18·8
4	45·10	6·06	24·09	21·4
5	55·03	7·12	40·21	18·9
6	57·95	7·43	39·43	19·7
7	61·21	8·17	45·06	19·5
8	61·75	8·43	44·42	19·0
9	59·90	9·27	41·33	22·1
10	61·04	9·25	40·47	21·6
11	57·32	9·21	41·03	22·6
12	54·23	9·45	41·49	23·5
13	49·87	9·01	41·94	24·8
14	43·49	8·34	41·12	26·8
S.E. per cent	13·16	9·92	7·63	
C.D. at 5 per cent	7·26	0·75	4·02	

* Leaf numbers 1 to 3 not included since they were dry at the time of harvest.

On the basis of weight of green leaves, the leaves may be broadly divided into two groups, the bottom-most four leaves and the top-most two leaves having relatively less weight than the middle eight leaves. The green weight followed the same trend as the area of the leaves. Thus, the decreased weight of the bottom-most four leaves and the top-most two leaves was due to their smaller size.

On the basis of weight of cured leaves, the leaves fall into two distinct groups. Leaves at positions one to four weighed significantly less than the other leaves. The top-most two leaves (leaves at positions 13 and 14) in spite of their relative smaller size and small green weight had relatively higher cured weight and did not form a separate group with the bottom-most four leaves. This is explained by the fact that at the time of stripping these leaves had higher moisture content than the bottom-most four leaves and also they contained more dry matter per unit area than any other leaf (*vide* Table IV).

Grade of leaves by number and weight

The results of grading the leaves according to their position on the stalk are given in Table V.

TABLE V

Good grade leaves of cigar tobacco according to leaf position on the stalk

Leaf position from bottom	Percentage of good grade leaf			
	By number		By weight	
	1952-53	1953-54	1952-53	1953-54
1	39·10	71·68	45·84	74·95
2	43·60	68·60	50·89	72·85
3	45·80	37·65	49·89	48·08
4	48·60	33·73	54·53	44·28
5	57·90	39·95	61·57	43·43
6	54·30	60·68	56·54	63·33
7	65·80	73·58	70·31	75·05
8	55·00	68·90	61·03	70·33
9	59·30	78·35	63·26	81·08
10	65·00	88·25	73·33	89·90
11	62·20	74·30	70·13	80·93
12	57·10	66·00	67·04	76·58
13	52·90	68·00	62·50	79·20
14	47·90	64·80	62·22	75·90

In 1952-53, leaves at positions 5 to 12 gave higher percentage (number) of good grade leaf than the bottom-most four leaves and the top-most two leaves. When graded by weight the bottom-most four leaves gave the lowest percentage of

good grade leaf. Leaves at positions 13 and 14 gave higher percentage (weight) of good grade because of their higher moisture and dry matter contents as already discussed.

In 1953-54, when the leaves at positions one and two were primed and cured separately, they gave, unlike in the previous year, higher percentage of good grade leaf by number and weight. On the other hand, due to priming of the leaves at positions one and two, the leaves at positions three, four, five and six gave the lowest percentage of good grade leaf.

In the field the bottom-most two leaves usually dry up and tend to come off from the stalk before the crop is harvested. They are, therefore, unavoidably damaged in the field and consequently give a larger percentage of inferior grade leaf. (This is also due to depletion of their contents by translocation to upper leaves.) This conclusion is substantiated by the grading data for the year 1952-53. In 1953-54 the leaves at positions one and two were primed 10 days after topping and cured separately. This procedure prevented their damage and gave a higher percentage of good grade leaf. However, the priming of the bottom-most two leaves adversely affected the leaves at positions three, four and five which gave a higher percentage of inferior grade leaf. This indicates that usually the bottom-most two leaves are of inferior quality and any attempt to improve them by priming and curing separately would damage the next two to five leaf positions through unduly hastening their maturity and also by mechanical injury. This suggests the advantage to leave two sand leaves at the bottom, usually removed at the time of topping.

Leaf-burn and cigar-burn tests

The values of leaf-burn and cigar-burn score for the two years are given in Table VI.

TABLE VI

Leaf-burn and cigar-burn score of cigar tobacco leaf according to position on the stalk

Leaf position from bottom	Leaf-burn in seconds			Cigar-burn score		
	1952-53	1953-54	Mean	1952-53	1953-54	Mean
1	3·68	1·76	2·72	*	14·88	*
2	3·29	2·36	2·83	*	15·50	*
3	3·02	1·90	2·46	21·88	20·75	21·32
4	3·86	2·30	3·08	21·13	16·63	18·88
5	5·49	3·19	4·34	21·50	18·50	20·00
6	5·76	2·94	4·35	20·88	23·75	22·32
7	4·12	8·75	6·44	21·00	24·13	22·57
8	4·92	11·78	8·35	20·38	24·50	22·44
9	6·27	9·27	7·77	19·50	24·75	22·13
10	4·58	8·53	6·56	22·50	24·88	23·69
11	3·42	7·80	5·61	20·88	25·00	22·94
12	4·50	8·09	6·30	26·00	25·50	25·75
13	3·48	5·66	4·57	20·88	22·38	21·63
14	4·59	6·01	5·30	27·25	22·75	25·00
S.E. per cent	24·7	33·1	31·09	10·92	10·73	11·04
C.D. at 5 per cent	0·95	1·69	0·98	2·39	2·32	1·73

* Not included as sufficient cigars could not be made for testing because of insufficiency of samples

The leaf-burn data indicate that the bottom-most four to six leaves had the poorest burn, the upper eight or ten leaves had distinctly better burn than the lower six or four leaves depending on whether the leaves at the positions one and two were primed or not; there was also an indication that the leaves at positions 13 and 14 had slightly less burn than the preceding six to eight leaves on the stalk. Johnson *et al.* [1944], on the other hand, observed that the leaf-burn of Wisconsin cigar tobacco decreased uniformly from bottom to the top; the burn of the bottom leaves was the best, of the top leaves the poorest and the middle leaves represented the average.

The inferior burning quality of the bottom-most four leaves could be explained by the fact that leaves at positions one and two tend to fall off from the stalk before the harvest; leaves at positions three and four also come off from the stalk when the plants are tied and turned on poles for sun curing. The moisture content of these four leaves, not attached to the stalk during curing and fermentation is much less than that of the other leaves [Table IV]. This appears to hinder their proper fermentation as moisture content is the most important factor controlling the character, rate and extent of fermentation of the leaf [Garner, 1951]. The bottom-most four leaves are usually raw and light brown in colour after curing and fermentation while the middle and top leaves attached to the stalk ferment well, develop good aroma and are dark brown to black in colour. The data in Table VI further indicate that leaves at positions five and six which gave good burn in 1952-53 had poor burn in 1953-54. This was due to the adverse effects of the earlier priming of leaves at positions one and two as discussed above and confirms that the lowermost leaves are poor in burn.

The cigar-burn score data indicate that there was not much variation in the cigar-burn scores of the cigars made from leaves at positions three to fourteen.

Considering the general quality of the leaf as judged by weight of cured leaf and percentage (weight) of good grade leaf obtained and the leaf burn data, it would appear that leaves at positions five to fourteen were the best while leaves at positions one to four were decidedly inferior.

Summary

Growth and quality of cigar tobacco leaf (*N. tabacum* var. *Vellaivazhai*) as influenced by its position on the stalk have been investigated. It was observed that when the cigar tobacco plant was topped leaving 14 leaves on the stalk, the bottom-most four leaves, which were more or less fully developed at the time of topping, developed very little afterwards. On the other hand, after topping new growth was mostly confined to the upper half of the plant, the top-most three leaves making more than 50 per cent growth. According to the local practice of grading, leaves at positions 5 to 14 gave higher percentage (weight) of good grade leaf than that given by leaves at positions one to four. Leaves at positions 5 to 12

had the best burn, leaves at positions 13 and 14 had medium burn while leaves at positions one to four had the poorest burn. Considering the general quality of the leaf, it was observed that leaves at positions 5 to 14 are better quality leaf than that obtained from leaves at positions one to four. The poor quality of the leaves at positions one to four may be due to their incomplete curing, fermentation and depletion of their contents by translocation to the upper leaves.

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STUDIES ON ROOT DEVELOPMENT IN GROUNDNUT

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A study of the root system of the groundnut plant was undertaken with a view to obtain precise information on the different stages of its development and the variations exhibited by the different varieties and forms and to find the relationship, if any, that exists between root development and other economic characters such as habit of growth, duration, yield, drought resistance under conditions obtaining in the typical groundnut tract of the Madras State as represented by the Agricultural Research Station, Tindivanam, South Arcot district.

Review of Literature

The root system of groundnut has been studied by a few workers previously. Reed [1924] confirmed the presence of root hairs and found that the groundnut has a well developed tap root. Ali Mohammed *et al.* [1933] studied the root system of three groundnut forms grown under irrigation and found the spreading form had much more vigorous growth than bunch forms. Badami [1935] from a study of the root system and the leaf structure concluded that the groundnut plant is well fitted to tide over periods of drought. Narasinga Rao [1936] studied the root systems of 85-day old plants of three groundnut forms and brought out some of their differences. Yarbrough [1949] has made detailed studies on the anatomy and development of the roots in the groundnut plant. Gregory, Smith and Yarbrough [1951] have discussed the development, morphology and anatomy of the roots. Harris and Bledsoe [1951] have reported on the intake of nutrient supply by the roots. But so far the root system does not appear to have been studied in different varieties and with different habits of growth.

Material and Methods

The study was taken up at the Agricultural Research Station, Tindivanam, Madras State, in light red sandy loam soil. Types with different habits of growth, viz. bunch, spreading, semispreading and trailing were studied under normal and wider spacings. The wider spacings (3 ft. $\times$ 3 ft.) were adopted in the later years of study as they gave a better picture especially of the root development free from competition from neighbouring plants. The root development in relation to drought resistance was studied in A.H. 1, A.H. 25 and A.H. 447 which are poorly, fairly and highly resistant to drought respectively. The detailed descriptions of varieties studied are given by John *et al.* [1954].

APPENDIX—A

Root studies in groundnut

Variety	Thickness of top roots in cm	Length of tap roots in cm	Penetration of tap root	Length of hypocotyl region in cm	Region of well developed primary laterals in cm	No. of well developed primary laterals	No. of well developed secondary laterals	No. of well developed tertiary laterals	Average spread of lateral roots in cm	Average penetration of primary lateral roots in cm	Total no. of nodules	Remarks
I Varietal studies (Spacing 3′ × 3′)												
A. H. 32	0·38	72·6	66·2	4·0	10·9	36	54	17	26·4	23·5	977	Average of 3 years
A. H. 45	0·41	64·2	60·8	3·8	7·5	28	39	5	29·0	21·4	746	Ditto
A. H. 1	0·50	65·5	59·0	4·5	11·5	30	62	35	23·5	19·5	1532	Average of 2 years
A. H. 25	0·55	68·9	62·5	4·5	10·2	30	70	46	24·5	24·1	1643	Average of 3 years
A. H. 784	0·45	73·5	65·0	5·3	11·7	27	67	39	25·5	25·0	1259	Average of 2 years
A. Nambyquarae	0·55	70·5	66·5	5·4	17·2	30	66	42	30·0	9·5	1052	Ditto
A. H. 32	0·49	55·0	54·58	4·8	8·8	87	59	..	23·7	18·7	2105	Only one year data
A. H. 45	0·52	62·5	54·5	4·5	4·8	25	11	..	35·7	24·1	830	Do.
A. H. 1	0·68	73·0	69·0	5·5	7·2	31	101	..	31·1	31·7	3496	Do.
A. H. 25	0·69	74·0	63·0	4·0	8·5	36	148	..	29·1	25·4	4288	Do.
A. H. 73	0·73	68·0	60·0	7·3	12·3	30	68	..	24·2	24·5	1921	Do.
A. H. 1723	0·78	53·0	50·0	3·0	9·0	36	135	..	39·0	18·0	1333	Do.
II Effect of spacing												
A. H. 32 6″ × 6″	0·32	59·0	57·0	3·6	9·8	29	14	..	18·0	10·0	227	Average of 2 years
3″ × 3″	0·41	77·0	71·0	3·6	11·8	27	44	20	26·0	21·0	825	Do.
A. H. 45 6″ × 6″	0·34	62·0	61·0	3·8	11·4	23	8	..	19·0	10·0	229	Do.
3″ × 3″	0·38	64·0	60·0	4·2	7·2	26	29	7	27·0	21·0	753	Do.
A. H. 1 9″ × 9″	0·36	66·0	60·0	5·4	13·8	27	26	8	20·0	11·0	490	Do.
3″ × 3″	0·50	66·0	59·0	4·5	11·5	30	62	35	24·0	20·0	1532	Do.
III Root development in relation to drought resistance												
A. H. 1	0·65	78·25	54·0	1·75	6·75	25	73	20	37·95	33·9	3105	Average of 2 years
A. H. 25	0·63	105·50	80·4	4·05	7·25	29	64	23	39·95	52·75	2428	Do.
A. H. 477	0·60	124·55	70·75	2·55	3·4	25	74	40	43·45	48·1	3029	Do.

The method of study was similar to the one used by Ali Mohammed and others [1933] and consisted of using a controlled spray of water to release the roots. The course of the tap root, the primary lateral roots, with their secondaries and tertiaries were traced out one after another. Their length, spread and penetration were measured and recorded. The presence of root nodules, their number, size and development were also noted. Field drawings of the root system were made as the study progressed.

Observations

The data obtained are given in Appendix A and the findings are briefly summarised below :

The tap root with a root cap covering the tender tip is clearly visible on the second day of germination. It grows and elongates rapidly almost vertically downward with slight bend along its course. But when a hard impenetrable obstruction is met with, a horizontal diversion is noticed till the obstruction is negotiated. On the tenth day, after sowing of the seed, i.e., when germination is complete, the tap root attains a length of 19 cm. to 30 cm. and penetrates to a depth of 21 cm. to 32 cm. Primarily laterals have developed and beginnings of secondaries are noted. The rate of development and elongation of the tap root at this stage is very rapid, 1·0 cm. to 1·5 cm. per day. The maximum development is reached when flowering commences. Later on there is very little increase in the length of the tap root, further activity being confined to its thickening and the development of the secondaries and tertiaries. At the final stages of the life of the plant, the tap root has a length of 50 cm. to 124 cm. with a penetration of 53 cm. to 80 cm. and with a thickness of 0·3 cm. to 0·5 cm. Badami [1935] has traced down the tap root of groundnut to 50 to 55 cm. in ill drained clayey soils. Bruner [1932] has observed root depth up to 3 or 4 feet. Therefore, the penetration of the tap root appears to be mainly determined by the nature of the soil profile.

The primary lateral roots make their appearance on the fifth day after germination in the top one-third region of the tap root. At this stage they are thin, few in number and very short in length, but their growth is somewhat rapid. On the tenth day when germination is complete, the number of laterals varies from 28 to 47 with an average length of 10 cm. They have a spread of 10 cm. to 13 cm. and penetration of 8 cm. to 12 cm. The beginning of secondaries is noted at this stage. The development of root system is marked during the second fortnight, i.e., at the time of first flowering. The tertiaries appear during the fourth fortnight and development in this stage, i.e., a month after flowering is in the direction of slight increase in length and thickness of primaries. When the plant is ready for harvest, the primaries are found to have developed from the first 7 cm. to 15 cm. of the tap root. This depth coincides with the top dark brown friable layer of the soil which is the cultivated portion. The side roots take an outward and downward course to a distance of 20 cm. to 40 cm. and then take a more or less downward average length of 44 cm. Their maximum spread and penetration are 23 cm. to 40 cm.

and 16 cm. to 53 cm. respectively. The total number of secondaries is between 11 to 148 and of tertiaries, 5 to 46. The average length of the former is 16 cm. and the later 10 cm. The total length of root system varies from 1,000 cm. to 10,000 cm. with an average of 5,000 cm. (55 yards).

The root nodules first make their appearance when the plants are about a fortnight old and are found in the first six inches of the soil. They occur singly and are spherical as in the case of lupin and are located in the root axils. [Allen *et al.* 1940]. In the present investigation it has been observed that two nodules sometimes appearing close to each other get coalesced and present the appearance of a big single nodule. In a mature plant the total number may be between 830 to 4,000 or more.

The general pattern of the root system is more or less similar in all the varieties and forms. The differences are not discernible in the first ten days of their growth and thereafter they are small and consist only in the degree of development. These are briefly indicated below.

In the bunch group (A.H.32), the root development in the early stages is of normal type and thereafter the growth is much more rapid than in the spreading ones and the full development is completed when the plants are about 55 to 60 days old.

In the spreading group (A.H. 1 and A.H. 25), the root development appears to be far superior than in the bunch; the number of nodules is nearly twice as much as in the bunch type and they are also bigger in size. The total root length, the length of tap root, the number of primaries, secondaries and tertiaries with their spread and penetration are far less in A.H. 1 than in A.H. 25. A.H. 1728 'Kurumani' (var. asiatica) shows a shallow root system but possesses the maximum total root length contributed by the large number of primaries.

Among the semi spreading types, the root development appears to be poor in A.H. 45 but well developed in A.H. 73 and A.H. 477. The root systems of the latter two types are better than in the bunch form A. H. 32 and are slightly inferior to the spreading form A.H. 25.

In trailing group (A.H. 784), the nature of development of root system is similar to that in bunch group excepting for the greater spread and larger number of secondaries and tertiaries.

During the course of the study it was observed that the development of the roots was largely influenced by the spacings adopted. Wider spaced plants generally showed better root development than those normally spaced. The increase was more evident in the long duration spreading types as compared with the bunch and semi spreading types. The increase in the number of secondary and tertiary laterals and the nodules is three or four fold in the spreading forms, and is less pronounced in the bunch forms. But wider spacing does not appear to alter the general pattern of root development.

It is possible that a well branched and deep root system is better able to tap the moisture in the lower soil regions than a shallow one. Thus the poorly resistant type A.H. 1 has a poorly developed root system as compared with those of A.H. 25

and A.H. 477. As between A.H. 25 and A.H. 477 though the differences in the root system are not large enough, the better drought resistant nature of A.H. 477 may be due to other factors physiological or anatomical.

Summary

The groundnut plant has a well developed root system. The lateral or feeding roots are much branched and form a network in the top 4 inches to 6 inches of the soil. The deep going roots penetrate to a depth of 2 feet or more depending upon the soil profile. Root nodules are present in large numbers but they are mostly concentrated in the top soil layer. The groundnut is essentially a shallow rooted plant.

Varietal differences in the root systems of plants with different habit of growth were noted. There was marked improvement in the development of root system due to increased spacing. Though a deeper and well developed root system can help in withstanding drought, the drought resistant nature of plants may be due to other factors also.

The spreading forms have greater number and bigger sized nodules than the bunch types. The nodules are concentrated in the top six inches of the soil and these are generally bigger in size than nodules found lower down. The nodules occurring on the tap root are bigger than those on the laterals. In favourable seasons a slight increase in the size of nodules has also been noted.

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EFFECT OF MOTTLING ON THE QUALITY OF WHEAT

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IN many hard-grained wheat types, three kinds of grains are often met with namely, (i) those which are entirely hard, also called by such names as flinty, vitreous translucent, glassy, dark red (in red-grained varieties) or amber (in the case of white-grained varieties); (ii) partly hard and partly soft, called piebald, semi-vitreous, semi-translucent; and entirely soft, called as mealy, opaque, starchy or floury. In some countries, for all non-translucent grains the term "yellow berry" or "mottling" is applied. It is a matter of common knowledge that traders, consumers, and wheat growers, all, prefer a translucent hard sample of wheat to a semi-translucent or opaque one. The purpose of this investigation, which was carried out in the pre-partition Punjab Agricultural College and Research Institute, Lyallpur, was to find out if any fundamental, substantial reasons are responsible for such a choice. Quality was judged on the basis of bushel weight, specific gravity, 1000-kernel weight, shape and size of kernels, protein content, baking properties and vitamin B_1 content; and in this paper the term translucent has been used in the sense of "unmottled", non-translucent in the sense of "mottled", semi-translucent in the sense of "partly mottled", and opaque in the sense of "completely mottled", as it were.

Bushel weight was included among points of quality as according to Bailey [1925] there is a close relationship between bushel weight and flour yield. Shollenberger [1925] found that average yield of flour for hard spring wheat weighing 63 lb. per bushel was 73·8 per cent, and that the average yield sank with the test (bushel) weight until 51 lb. wheat yielded but 62·8 per cent of flour. Alsberg [1934] also, after reviewing the literature, came to the conclusion that weight per bushel is directly correlated with flour yield. Specific gravity and 1000-kernel weight were included among points of quality as higher are the values of these factors of wheat kernels, greater is the amount of edible portion yielded by a given number of grains. Shape and size of kernels were included among points of quality as on these depends the attractiveness of a sample. Grains of wheat vary greatly both in shape and size, and uniformity or otherwise in these two characteristics is mostly responsible for the general appearance of a wheat sample. An ideal wheat sample must be such that there is very little variation in the size and shape of its grains and each grain is symmetrical with such a ratio between its length and width as to make it appear like an ellipsoid. Protein content was included among points

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of quality as from the nutritional point of view this is the most important constituent of the wheat grain. Baking property was included among points of quality as the baking test is the ultimate criterion by which quality of a bread wheat is judged. Baking tests were carried out both by preparing leavened bread and *chapatis* (Indian unleavened pan cakes). Lastly, vitamin B_1 was included among points of quality as wheat, being a cereal, is one of the chief sources of this vitamin, the absence of which causes beri-beri.

Material and Method

For carrying out these investigations, grains from samples of each of Punjab wheats 8A, 9D and C518, and occasionally C591 also, were assorted into translucent, semi-translucent and opaque types for determining each of the quality points enumerated above. The findings which were made were briefly as follows:

(1) In bushel weight, the three types of grains stood, on the average of all the wheats employed in the investigation, in the order of translucent (65·38 lb.)>semi-translucent (64·81 lb.)>opaque (63·88 lb.). However, correlation which gives in a single mathematical figure the mutual or reciprocal correspondence and relationship between two or more traits, characters or sets of values and is an index of the degree of relationship between such sets of varying value, worked out between mottling percentage and bushel weight from the detailed figures was found to be $0{\cdot}059 \pm 0{\cdot}04$, which is very low and non-significant. This means that the various differences of bushel weight among the three types of grains were not significant.

(2) In specific gravity the three types of grains stood, on the average, in the order of translucent (1·40468)>semi-translucent (1·39595)>opaque (1·38176). These differences were found to be due to a lesser amount of air being present in the endosperm of translucent grains than in the endosperm of semi-translucent ones, and again a lesser amount of air being present in the endosperm of semi-translucent grains than in that of opaque ones. In 50 grammes of each of translucent, semi-translucent and opaque grains, the amount of air found was 0·43cc., 0·80cc. and 1·60cc., respectively, which in terms of 100cc. volume of each works out to 1·20cc., 2·24cc. and 4·42 cc. respectively.

(3) In 1000-kernel weight, the three types of grains stood, on the average, in the order of translucents (34·000 gm.)>semi-translucents (33·385 gm.)>opaque (29·857gm.). From this it will be seen that while the difference in this respect between the translucent and the semi-translucent was nominal, i.e. only about 1·8 per cent, differences between the translucent and the opaque, and between the semi-translucent and the opaque were considerable, i.e. 13·9 per cent and 11·8 per cent, respectively. Comparative weight lowness of opaque kernels may be due to the fact that opaque grains, being generally found in the secondary florest of a wheat ear, are placed disadvantageously with regard to nourishment supplies and remain, therefore, comparatively small. The other probable reason of their low weight may be their lower specific gravity due to the presence of more air spaces in them and, as will be shown later, due to their low nitrogen or protein content.

(4) In respect of mean length, the three types of grains stood in the order of translucent (0·6185 cm.)>semi-translucent (0·6007 cm.)>opaque (0·5791 cm.), with variance of means of 0·0669, 0·0777 and 0·1059, respectively, showing thereby that in uniformity of length of grains also they stood in the order of translucent>semi-translucent>opaque. Independently of the consideration of greater uniformity in length of translucents, translucency in itself imparts to grains a pearlaceousness which makes such grains look more attractive than the semi-translucent and the opaque, the first one of which latter two, on the other hand, look analogous to a disfigured man infected with leprosy, and the second analogous to a pale-faced individual suffering from anaemia. In respect of lateral width, however, it was the semi-translucent which stood at the top (0·2959cm.), followed by the translucent(0·2886 cm.) and the opaque (0·2836 cm.). This means that semi-translucent grains are more oval in shape than translucent grains. It appears that cheeks of translucent grains are rather angular, while those of semi-translucent grains are round and bulging out, for which reason in the latter type of grains lateral width measures more than in the former. This difference becomes more clearly marked if the ratio of breadth to length is worked out by taking length as a unit, which ratio amounts to 0·467, 0·492 and 0·495 for the translucent, the semi-translucent and the opaque, respectively. In respect of dorso-ventral width, they again stand in the order of translucents (0·2656 cm.)>semi-translucent (0·2654 cm.)>opaques (0·2557 cm.). But if the ratio of dorso-ventral width to length is worked out by taking length as a unit, the order is reversed to opaques (0·445)>semi-translucents (0·442)>translucents (0·429). All this shows that translucent grains are longer, more uniform in length and more attractive looking than non-translucent grains, the last so both by virtue of their greater uniformity in length and of their translucency, while the latter (non-translucents) are more oval in shape than the former (translucents).

(5) In respect of protein content they stood in the order of translucents (11·43 per cent)>semi-translucents (8·96 per cent)>opaques (8·51 per cent). From this it will be seen that the translucent grains averaged markedly higher in protein content than the semi-translucent and the opaque (by 2·47 per cent and 2·92 per cent respectively), but the superiority of the semi-translucent over the opaque is only nominal (i.e. 0·45 per cent). Coefficient of correlation worked out between mottling percentage and nitrogen or protein content, taking all the non-translucent grains as mottled whether they were semi-translucent or opaque, ranged from $-0{\cdot}413 \pm 0{\cdot}0932$ to $-0{\cdot}654 \pm 0{\cdot}0357$, which correlations are negative, high and significant. This means that the relationship between mottling percentage and nitrogen or protein content is such that with an increase in mottling a decrease occurs in nitrogen or protein content or, to put it in another way, the deviation in mottling towards high percentage tends to be associated with corresponding deviation of nitrogen or protein content in the opposite direction. From this the implication is clear that translucent grains would show a positive correlation with nitrogen content. This was confirmed by studies carried out on 38 samples of Punjab wheats. The coefficient of correlation obtained in this case was $+0{\cdot}819 \pm 0{\cdot}035$, which is positive, significant and very high, showing thereby that with an increase in the number

of translucent grains there is a corresponding increase in the nitrogen (or protein) content of the grain. This being the case, it should be possible to foretell with a reasonable degree of accuracy from the visual examination of a sample alone as to whether it has a high or low nitrogen (or protein) content. Protein content in these investigations was taken to be equal to nitrogen percentage $\times 5{\cdot}7$.

As to why a high protein content increases the translucency of the grain and a low protein content gives rise to mottling, Nowacki [1870] and Wollny [1886] gave the explanation that if the protein fills the spaces between the starch grains, the kernel is corneous or translucent, but if air is present in these spaces, the kernel is mealy. Hackel [1890] says "If the albuminoids so fill up the intervals between the starch grains that the latter seem to be imbedded in cement, the albumin appears translucent and the fruit is called corneous, but if the union is less intimate, there remain numerous small air cavities and the albumin appears opaque and the fruit is mealy : both conditions may occur in the same species of variety". Lyon and Keyser [1905] and Roberts and Freeman [1908] also confirmed this view. Freeman [1918] is of the opinion that hardness of a wheat is determined by the solidity of the grain, and this, in turn, by the nature and proportions of gluten and starch in the endosperm. When the ratio of gluten to starch is sufficiently high, the entire cell contents are cemented together solidly as the grain dries out in ripening. It therefore takes on a hard, glassy, semi-translucent texture. In the absence of a sufficient proportion of gluten to hold the cell contents together, the shrinkage in drying does not fully make up for the loss of water, and air spaces appear within the cell. These open spaces render the grain soft and also, since they serve as refracting surfaces, make it opaque. In true soft wheats air spaces in endosperm are diffused and finely scattered, while in yellow berry air spaces are in flake-like groups with quite definite margins. Sharp [1927] says that "it is possible that the proteins of different wheats may vary in their ability to contract the cells of the wheat kernels as the moisture is removed, and it is not impossible that different parts of the same ear and kernel may be subjected to different moisture conditions during the dessication of the kernels". Fisher and Jones [1932] say that when the fully expanded wheat kernel, containing well over 40 per cent of water, starts to dry out, the nitrogenous bodies "condense" to form the meshwork of gluten which permeates the endosperm binding the whole together. As drying proceeds, shrinkage occurs and a strain is set up throughout the endosperm. If the strain is withstood until the grain has dried to its normal moisture content, the kernel remains translucent throughout, it is vitreous, flinty or hard. If the strain is not withstood, minute cracks appear in the endosperm, which appear more or less opaque or starchy. Starchy grains do not look starchy because they have more starch but simply owing to the presence of these cracks. Now whether or not the strain is withstood, probably depends upon a number of factors including size and shape of the kernels and the manner and rate of drying out, but above all it depends upon two things : (1) amount of the protein, (2) special characteristics of the protein. Roughly speaking, the more the protein the denser and stronger the mesh work. To some extent, of course, the possession of special characters in marked degrees can compensate for shortage

of protein, the more sparsely distributed network of better character standing the greater strain. According to Alsberg [1935], the starch in different kinds of wheat bears different relation to the gluten and this, in a measure, determines the gross appearnce of the kernels. With a sufficiently high ratio of gluten to starch, the starch and the gluten are cemented together solidly as the grain dries out in ripening and the kernel appears vitreous or flinty, while in the absence of sufficient gluten air spaces appear rendering the grain soft and also serving as light—refracting surfaces that make the grain appear opaque. A true soft wheat naturally has the air spaces diffusely scattered throughout the interior of the berry, i.e. through the endosperm. When grown under unfavourable conditions, normally vitreous wheat varieties may assume the appearance of soft wheat in variable degrees. The opaque soft part may be localized in a part of the berry or in spots. The air spaces to which this appearance is due are then localized in these areas ; they are not diffusely distributed throughout the endosperm as in a genuine soft wheat.

(6) In respect of leavened bread baking properties as judged by loaf volume a correlation of $+0{\cdot}439 \pm 0{\cdot}088$ was obtained between percentage of translucent grains and loaf volume, which is positive, high and significant, showing thereby that a close relationship exists between these two factors. Existence of this close relationship between percentage of translucent grains and loaf volume was of course due to the fact that a correlation of $+0{\cdot}582 \pm 0{\cdot}072$ had been found to exist between protein content and loaf volume and, as already reported, a correlation of $\pm 0{\cdot}891 \pm 0{\cdot}035$ between percentage of translucent kernels and protein content, and not due to any partial (net) correlation between the two (percentage of translucent grains and loaf volume), which was found to be only —0·087 when protein content was held constant.

(7) *Effect of mottling on* chapati (*unleavened pan cakes*) *making properties.* In India, wheat is chiefly consumed in the form of *chapatis*. This being the case, it was considered highly desirable to determine the effect of differences in endosperm textures, if any, on their *chapati* making properties, in addition to testing their baking qualities according to the fermented bread making method. With this object in view, a sample of C591 was divided into translucent and non-translucent lots by hand picking of grains and the two lots were ground into *atas* (wholewheat meals) by means of a hand-driven *chakki*. The *atas* from the two different lots were supplied in pairs (under code numbers) to a number of different persons for preparation of *chapatis* therefrom and for expression of their opinions on the comparative qualities in this respect of the two lots. The consensus of opinion in all cases was that *ata* from translucent (unmottled) grains absorbed more water during kneading and the dough made therefrom was more glutenous and that *chapatis* made therefrom were better, more tasteful and superior in keeping quality to those made from non-translucent (mottled) grains.

(8) *Effect of mottling on vitamin B_1 content of kernels.* The cereals are the chief source of vitamin B_1 in nature, the absence of which causes beri-beri. To see whether there is any variation with regard to this vitamin in kernels of different endosperm structures, the kernels were tested by means of biological assay which is the only

satisfactory method of determining this vitamin. Two kinds of grains, viz. translucent (unmottled) and non-translucent (mottled) were hand-picked from a common sample of wheat C591 and sent to Dr. H. Ellis C. Wilson, Professor of Biochemistry and Nutrition, All-India Institute of Hygiene and Public Health, Calcutta, who tested these samples and supplied the following results :

Vitamin B_1 per 100 grammes	
Translucent (unmottled)	77 units
Non-translucent (mottled including opaque)	62 units

From these figures it is clear that translucent (unmottled) kernels contain more vitamin B_1 than non-translucent (mottled) grains. This is in accordance with the finding of Munsell and De Vaney [1933], who analysed the vitamin B_1 content of wheat germ and showed that germs of hard (translucent) wheat are richer in vitamin B_1 content than germs of soft wheat.

Discussion

In view of the above findings, it becomes imperative that texture of wheat kernels should occupy a prominent place in grading commercial wheats in India. In other countries, the texture of wheat kernel is taken as one of the important factors in grading wheat. For example, in Canada No. 1 Manitoba Hard wheat contains 80 per cent hard vitreous (unmottled) kernels, while Nos. 1, 2 and 3 Manitoba Northern contain 65, 50 and 25 per cent, respectively. Similarly in U.S.A., kernel textures are taken into account in distinguishing between sub-classes of a wheat, i.e. in Hard Red Spring wheat there are sub-classes, viz., a, b & c, the respective percentage of hard vitreous kernels in these being 75 or more, 25 to 75, and less than 25 per cent. In Argentina, too, Grade No. 1 and Grade No. 2 contain 85 and 70 per cent, of kernels free from yellow berry respectively [Fisher and Jones, 1937]. But it is a pity that no such account of kernel texture is taken in grading commercial wheats in India.

Summary

Conclusions arrived at as a result of this investigation are summarized below :

I. (*a*) Weight per bushel is somewhat higher of translucent (unmottled) grains than of opaque (completely mottled) ones.

(*b*) There is not much difference in bushel weight between translucent (unmottled) and semi-translucent (partly mottled) grains.

II. (*a*) Translucent (unmottled) grains have a somewhat higher specific gravity than semi-translucent (partly mottled) ones, and the latter in turn slightly higher than opaque (completely mottled) ones.

(*b*) The higher specific gravity is in all cases due to a lesser amount of air being present in the endosperms of those having higher specific gravity than in the endosperms of those having lesser specific gravity.

III. Translucent (unmottled) grains weighed only nominally higher than semi-translucent (partly mottled) ones, which latter, however, weighed considerably higher than the opaque (completely mottled) ones.

IV. In respect of length and uniformity thereof, translucent (unmottled) grains score over non-translucent (mottled) ones, and they are also more attractive looking than the latter—and that both by virtue of their greater uniformity in length and of their translucency.

V. (*a*) Translucent (unmottled) grains have a markedly higher protein content than semi-translucent (partly mottled) ones, which latter in turn have a somewhat higher protein content than opaque (completely mottled) ones.

(*b*) Correlation between mottling percentage and protein content, being from $-0{\cdot}4134 \pm 0{\cdot}0932$ to $-0{\cdot}654 \pm 0{\cdot}0357$, is negative, significant and high.

(*c*) Correlation between the percentage of translucent (unmottled) grains and protein content, being $+0{\cdot}819 \pm 0{\cdot}035$, is positive, significant and very high.

VI. (*a*) Correlation between the percentage of translucent (unmottled) grains and loaf volume (in cc.), being $+0{\cdot}439 \pm 0{\cdot}088$, is positive, high and significant, showing thereby that with an increase in the percentage of translucent (unmottled) grains there occurs an increase in loaf volume, i.e., an increase in the quality of loaf.

(*b*) *Chapatis* (unleavened pan cakes) made from translucent (unmottled) grains are decidedly superior to those made from non-translucent (mottled) grains.

VII. Translucent (unmottled) kernels contain more vitamin B_1 than non-translucent (mottled) ones.

VIII. In view of the above findings, it is suggested that texture of wheat kernels should occupy a prominent place in grading commercial wheats in India as it does in countries like Canada, U.S.A. and Argentina.

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A MOSAIC DISEASE OF PAPAYA IN BOMBAY

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(With 1 Text-Figure)

A mosaic virus affecting papaya (*Carica papaya* L.) was discovered in 1947 in the Bombay State [Capoor and Varma, 1948]. The disease is not only confined to Bombay State, but has since been observed and identified from various places in Central India, Uttar Pradesh, Bihar, Bengal including the Darjeeling District of West Bengal, and Hyderabad. It has, however, not yet been observed in Delhi proper and the North Kanara District of the Bombay State.

A few virus diseases of papaya have been reported earlier from this country [Thomas, 1939 ; Thomas and Krishnaswami, 1939 ; Sen, Ganguly and Mallik, 1945]. Similarly, a number of virus diseases affecting papaya have been reported from various countries and these have been adequately reviewed by Jensen [1949a].

Work on the mosaic disease was carried out from 1947 to 1952 and the results are presented here.

Material and Method

The virus was collected from a naturally infected papaya and its culture was maintained by juice inoculating the glasshouse grown seedlings of *Carica papaya* var. Washington Special. Papaya seedlings and all other plant species used in host range studies were raised from seed and grown in well composted soil in 6-or 8-inch pots under insect proof conditions.

Locally, papaya has not been observed to be infested by insects. Therefore, populations of aphids were collected from their preferred breeding host plants growing near papaya plantings. These collections included both the alate and the apterous viviparous females. The aphids were starved for two to three hours, allowed to feed on young leaves of recently infected papaya, and after infection feeding transferred to healthy test plants.

Symptoms of disease in papaya

Papaya plants contact the disease at all stages of growth but are seriously affected when about a year old. The initial symptoms of papaya mosaic vary both in naturally infected and in experimentally infected plants. In nature the infection is carried mostly through the agency of the aphid vectors and can, therefore, be made out only by profusely mottled and puckered symptoms in younger foliage

(Plate I, Fig. 1). Within about 30 to 40 days after the appearance of the first symptoms the infected plants show degeneration and a marked reduction in growth. The younger leaves are very much reduced in size, become chlorotic and malformed, and the older ones gradually fall off leaving the trees almost denuded except for a tuft of small leaves (Plate I, Fig. 2). Often conspicuous dark green spots and elongated streaks of ' water-soaked ' areas or 'oil-spots' are formed on the petioles and the stem of diseased trees. The fruits produced on such trees also develop innumerable circular or concentric ' water-soaked ' lesions with a central solid spot (Plate, I Fig. 3). The diseased papaya trees are not killed by the virus but linger on for months, and both the fruits as well as the trees continue to show flow of latex in them.

In experimentally inoculated papaya plants the first symptoms were faint chlorotic spots which appeared on the inoculated leaves in about 6 to 8 days followed by premature drooping and wilting of the leaves (Plate I, Fig. 4). Subsequent leaves showed mild chlorotic spots with a speck of necrosis in the centre, but were not killed (Plate I, Fig. 5). All growth which followed showed the characteristic mosaic mottling accompanied by puckering and large blister-like islands of deep green areas (Plate I, Fig. 6). As the disease progressed the young developing leaves were much reduced in size and occasionally deformed. ' Water-soaked ' areas or 'oil-spots' and elongated streaks were also common on juice-inoculated papaya plants.

Transmission of the virus

The virus was readily transmitted to healthy papaya plants by means of juice inoculation by the leaf-rubbing method with or without the use of an abrasive, and by grafting. Papaya plants were grafted by means of wedge-grafts and also by budding according to the 'forkert' method [Clair Fielden and Garner, 1940]. The virus was transmitted in 29 out of 40 plants grafted by wedge-grafts and in all the 12 plants which were budded in 35 to 70 days, but in case of juice inoculated papaya plants disease appeared in 15 to 26 days. The virus was not carried in the seed of diseased plants.

Papaya plantations were regularly surveyed for insects breeding on papaya, but a serious infestation of papaya by insects was never observed. Some white-flies (*Bemisia tabaci* Gen.), an unidentified fulgorid and immature stages of *Myzus persicae* (Sulz.) were occasionally collected. The red spider mite (*Tetranychus* sp.) is the only arthropod commonly breeding on papaya specially during the warmer months of the year. Therefore, the aphid species used in transmission experiments were collected from host plants growing near papaya plantings. The banana aphis, *Pentalonia nigronervosa* Coq., was collected from banana ; *Myzus persicae* from cabbage ; *Aphis malvae* Koch. from bottle-gourd (*Lagenaria siceraria* Standl.) and from snake-gourd (*Trichosanthes anguina* L.) ; *Aphis gossypii* Glover from cotton and hollyhock ; *Aphis medicaginis* Koch. from *Sem* (*Dolichos lablab* L.) ; *Macrosiphum sonchi* L. from safflower (*Carthamus tinctorius* L.) ; *Aphis* sp. from

(See explanation of Figs. on the back of the Plate)

EXPLANATION OF FIGURES OF PLATE I

Fig. 1.—Naturally infected papaya showing mosaic mottling of leaves. Early symptoms.

Fig. 2.—Papaya tree almost denuded due to mosaic infection.

Fig. 3.—Papaya fruit from a diseased tree with circular ' water-soaked ' or oily lesions.

Fig. 4.—Papaya seedling showing first symptoms of the disease following juice inoculation.

Fig. 5.—Leaf of infected papaya showing the primary systemic infection.

Fig. 6.—Papaya leaf showing typical mosaic with dark-green blisters.

Fig. 7.—Leaf of *Lagenaria siceraria* showing vein clearing and discoloration in patches.

Fig. 8.—Leaf of snake-gourd infected with the virus, showing chlorotic spots.

Fig. 9.—Leaf of snake-gourd showing secondary 'water-soaked' areas or spots.

Fig. 10.—Leaf of pumpkin showing chlorotic patches and some distortion.

Fig. 11.—Leaf of cucumber showing mild mosaic of light and dark-green areas.

Euphorbia hirta L. ; *Aphis nerii* B. de F. from *Calotropis gigantea* R. Br. and the brown citrus aphid, *Toxoptera citricidus* Kirk, from lime (*Citrus aurantifolia* Swingle).

The aphids were fed first on diseased plants for 2 to 8 hours in groups of 30 to 50 individuals consisting either of purely apterous females or of both the alatae and apterae, and then for the same period on the test plants. The virus was successfully transmitted by *Myzus persicae*, *Aphis malvae*, *A. gossypii*, *A. medicaginis*, *Aphis* sp. and *Macrosiphum sonchi* (Table I).

TABLE I

Transmission of papaya mosaic virus by aphids .

Aphid species	Individuals per plant	Feeding period on diseased plant	Feeding period on test plant	Plants colonised	Plants infected
		(hours)	(hours)		
Myzus persicae	30 mixed	2	6	5	3
	40 mixed	4	6	4	4
	50 apterae	4	4	6	5
Aphis malvae	40 mixed	2	2	4	2
	40 mixed	4	3	3	3
	50 apterae	2	8	5	3
A. gossypii	40 mixed	4	6	5	3
	50 apterae	2	4	3	2
	30 mixed	4	2	6	2
	20 apterae	2	8	3	1
A. medicaginis	30 apterae	4	6	4	2
	30 mixed	3	8	3	1
	30 mixed	2	4	2	0
	50 apterae	3	6	5	2
Aphis sp.	20 apterae	4	4	5	1
	25 mixed	2	2	5	2
	30 apterae	2	6	5	1
Macrosiphum sonchi	50 apterae	4	3	4	1
	20 alatae	2	2	2	0
	30 mixed	3	4	5	1
	50 alatae	3	4	3	1

It is obvious that *Myzus persicae*, *A. malvae*, *A. gossypii*, and *A. medicaginis* are more efficient vectors of the virus than *Macrosiphum sonchi* and *Aphis* sp. Other insects under test failed to give positive infection.

Retention of the virus by aphids

Experiments were conducted to determine the length of time *Myzus persicae* and *Aphis gossypii* would retain the virus after having fed upon a diseased plant. In this test only apterous viviparous females were used.

Groups of 20 to 30 *M. persicae* and *A. gossypii* were fed on mosaic affected papaya for 10 and 24 hours, respectively, and then transferred to healthy test plants at intervals of one hour. The results obtained in several such tests involving serial transfers of aphids to 3 to 5 healthy papaya plants showed that *Myzus persicae* was able to infect 3 out of 10 plants of the second series, but *A. gossypii* did not infect any plant after it had fed on the first set of healthy plants (Table II). The virus, therefore, is of the non-persistent type [Watson and Roberts, 1939].

TABLE II

Retention of the mosaic virus by aphids

Aphid species	Serial number of test	Infection in plants on successive transfers at intervals of one hour				
		1st	2nd	3rd	4th	5th
Myzus persicae	1	+	—	—	—	—
	2	+	+	—	—	—
	3	+	—	—	—	—
	4	+	+	—	—	—
	5	+	—	—	—	—
	6	+	+	—	—	—
	7	+	—	—	—	—
	8	+	—	—	—	—
	9	+	—	—	—	—
	10	+	—	—	—	—
Aphis gossypii	1	+	—	—	—	—
	2	+	—	—	—	—
	3	+	—	—	—	—
	4	+	—	—	—	—

Host range of the virus

Fifty six species of plants representing 15 families were inoculated with the virus in order to study its host range. In addition to papaya the virus infected 9 species in the family Cucurbitaceae. The symptoms of disease on these plants are described briefly :

Carica papaya vars. Poona Long, Poona Round, Bombay, Ceylon, Ranchi, Honey Dew and Hawaiion were readily infected by juice inoculation and symptoms of disease produced in them were similar to those described on papaya var. Washington Special.

Lagenaria siceraria Standl. Of 61 plants inoculated by juice, only 6 were infected and the disease appeared in the form of a mild green mosaic in young leaves. Subsequent leaves showed vein-clearing and some discoloration in patches (Plate I, Fig. 7), but leaves showing severe malformation were often produced.

Tricosanthes anguina L. Snake-gourd showed the first signs of infection as a mild mosaic mottle in 12 days after inoculation, and the younger leaves developed chlorotic spots in addition (Plate I, Fig. 8). Later, ' water-soaked ' areas or ' oil-spots ' appeared on the under side of leaves (Plate I, Fig. 9) which were also reduced in size but not malformed.

Cucurbita maxima Duchesne.—Pumpkin was readily infected with the virus and showed mosaic symptoms similar to those in *L. siceraria* in the early stages of infection. Later leaves developed chlorotic patches with some distortion of lamina (Plate I, Fig. 10).

Cucurbita pepo L. and *C. pepo* L. var. *medullosa* Alef. Both squash and vegetable marrow developed mild mosaic mottling and scattered pale green spots. Leaves were not distorted but reduced in size.

Citrulus vulgaris Schrad. and *C. fistulosus* L. Water-melon and *Dilpasand* are highly susceptible to the mosaic virus. Both developed a severe mosaic with dark green blisters all over the leaf blade. A marked reduction in leaf size and growth of vines was also noticed.

Cucumis sativus L. and *C. melo* L. Cucumber and musk-melon developed vein-clearing in patches followed by mild mosaic of green and light-green areas (Plate I, Fig. 11), and the leaves were slightly distorted.

Luffa acutangula Roxb. Faint mosaic mottle appeared on younger leaves after 18 days of inoculation and subsequent growth showed chlorotic spots in addition, but there was no malformation or reduction in leaf size.

The following plant species were not infected, nor was the mosaic virus recovered from them in healthy papaya seedlings. These plants are, therefore, immune to the virus.

APOCYNACEAE—*Vinca rosea* L.; BALSAMINACEAE—*Impatiens balsamina* L.; BORAGINACEAE—*Cynoglossum grande* Dougl.; CAPPARIDACEAE—*Cleome spinosa* L.; CHENOPODIACEAE—*Beta vulgaris* L., *Spinacia oleracea* L.; CONVOLVULACEAE—*Ipomoea batatas* Lam.; COMPOSITAE—*Helianthus annuus* L., *Zinnia elegans* Jacq., *Helichrysum* sp. Gaertn., *Callistephus hortensis* Cass.; CRUCIFERAE—*Raphanus sativus* L., *Brassica oleracea* L. var. *capitata* L.; CUCURBITACEAE—*Momordica charantia* L., *Benincasa hispida* Cogn., *Luffa cylindrica* Roem.; GERANIACEAE—*Pelargonium hortorum* Bailey; LEGUMINOSEAE—*Cajanus cajan* Mill sp., *Crotalaria juncea* L., *Cyamopsis tetragonoloba* (L.) Taub.; *Dolichos lablab* L., *D. biflorus* L., *Desmodium laxiflorum* DC., *Phaseolus vulgaris* L., *P. vulgaris* L. var. Scotia, *P. limensis* Macf., *Vigna sinensis* Savi var. New Era, *V. cylindrica* Skeels, *V. sesquipedalis* Fruwirth; MALVACEAE—*Abelmoschus esculentus* Moench.; POLIGONACEAE—*Rumex scutatus* L.; SOLANACEAE—*Capsicum frutescens* L., *Datura inoxia* Mill., *D. stramonium* L., *D. metel* L. var. *fastuosa* L., *Nicotiana tabacum*

L. var. White Burley, *N. glutinosa* L., *N. rustica* L., *N. glauca* Grah. (*N. tabacum*× *N. glutinosa*) hybrid, *Nicandra physaloides* Gaertn., *Lycopersicon esculentum* Mill., *Physalis peruviana* L., *Petunia hybrida* Vilm., *Solanum melongena* L., *S. nodiflorum* Jacq., and TROPAEOLACEAE—*Tropaeolum majus* L.

Incidentally, it is of interest that of all the papaya viruses reported from various countries, the papaya mosaic reported herein is the only virus that is found to infect plants other than papaya, except that *Melothria guadalupensis* (Spreng.) Cogn. is reported to be a symptomless carrier of the Puerto Ricon papaya mosaic virus [Adsuar, 1950].

PHYSICAL PROPERTIES OF THE VIRUS

(*a*) *Thermal inactivation.* Ten ml. of crude infective juice contained in thin-walled tubes were heated in a water-bath for ten minutes to the desired temperatures (±0·5°C.). The combined results of the experiment and one replication were : Unheated control, 25/25* ; 50°C., 25/25 ; 53°C., 17/25 ; 55°C., 0/25 ; and 60°C., 0/25. The virus was completely inactivated at 55°C. but not at 53°C. with a 10 minute exposure.

(*b*) *Dilution end-point.* Crude juice was diluted with distilled water to the required dilutions and tested on papaya seedlings. The results were : Undiluted, 40/40* ; 10^{-1}, 40/40 ; 10^{-2}, 30/40 ; 10^{-3}, 1/40 : 10^{-4} 0/40 ; and 10^{-5}, 0/40. Since only one positive infection was obtained with 10^{-3} dilution, the dilution end-point of the virus lies between 10^{-4} and 10^{-3}.

(*c*) *Longevity* in vitro. To test the tolerance to ageing of the virus *in vitro*, 10 ml. of the crude infective juice were stored in cotton-plugged tubes at room temperature (approximately 24°C.). The test was replicated twice and the combined results were : 0 hour, 5/5* ; 4 hour, 16/16 ; 8 hour, 16/16 ; 16 hour, 16/16 ; 20 hour, 16/16 ; 22 hour, 11/16 ; 24 hour, 10/16 ; 26 hour, 5/16 ; 28 hour, 0/16 ; and 30 hour, 0/16. The virus survived ageing *in vitro* for 26, but not for 28 hours.

DISCUSSION

Although virus diseases of papaya have been reported from many countries [Jensen, 1949a] in addition to India, only a few of these have been studied. These include the bunchy top and the papaya mosaic reported from Puerto Rico, the Waialua disease and the papaya ringspot of Hawaii, and the mosaic disease of papaw in Venezuela [Pontis Videla, 1953]. In most of the remaining cases only symptoms of the virus diseases have been described. Therefore, only five viruses which have been studied in some detail call for comparison with the mosaic of papaya reported herein.

The papaya mosaic in Bombay does not resemble the bunchy top of Puerto Rico because the latter is not juice transmissible and is transmitted in nature by a leaf-hopper, *Empoasca papayae* Oman [Adsuar, 1946a ; Sein and Adsuar, 1947]. It,

* Numerator shows the number of plants infected, and the denominator the number inoculated.

however, resembles in symptom picture and its transmission by means of aphids, by grafting or by mechanical means the papaya mosaic of Puerto Rico [Adsuar, 1946b, 1946c ; Martorell and Adsuar, 1952], the Waialua disease [Parris, 1938, 1941], and the ringspot virus of Hawaii [Jensen, 1946, 1947, 1949a ; Hendrix and Matsuura, 1947], and the mosaic disease of papaw reported from Venezuela [Pontis Videla, 1953]. Also, the physical properties of the papaya mosaic virus reported herein compare favourably with those of the Puerto Ricon papaya mosaic virus [Adsuar, 1946d].

From this account it is quite obvious that the papaya mosaic in Bombay, the Puerto Ricon mosaic disease, the ringspot and the Waialua disease of Hawaii, and the mosaic disease of papaw in Venezuela are all caused by the same virus which is non-persistent, aphis-borne and mechanically transmitted, or by the strains of one virus. This statement is further substantiated by the fact that the Puerto Ricon papaya mosaic virus and the ringspot virus of Hawaii are also not retained by the aphid vectors beyond the first healthy papaya fed upon by them [Adsuar, 1946d ; Jensen, 1949b]. Our papaya mosaic was retained by *Myzus persicae* in a few cases beyond the first healthy papaya fed upon but not for more than two hours (Table II).

Since the mosaic disease of papaya in Bombay has been studied in detail in all its aspects, we propose to name it "*papaya mosaic*" virus. It is classified as *Carica* virus 1 according to Smith [1937], and designated as *Marmor papayae* n. sp. according to Holmes [1948].

Tentatively the virus diseases of papaya are divided into two main groups (*a*) the 'mosaic' group consisting of the non-persistent aphis-borne mechanically transmitted viruses, such as, *Carica* virus 1, ringspot and Waialua disease of Hawaii, papaya mosaic of Puerto Rico, and the mosaic disease of papaw of Venezuela and the (*b*) group consisting of the persistent viruses which are not transmitted mechanically, such as, papaya bunchy top of Puerto Rico. The relationship of the remaining papaya viruses can be established only when complete knowledge about their properties, transmission and host range is available.

Summary

The mosaic of papaya (*Carica papaya* L.) prevalent in the Bombay State has been studied and the symptoms of the disease described. The virus is not carried in seed of papaya, but is readily transmitted by juice inoculation, by grafting, and by the aphids *Myzus persicae* (Sulz.), *Aphis malvae* Koch., *A. gossypii* Glover, *A. medicaginis* Koch., *Aphis* sp., and *Macrosiphum sonchi* L. Of these *Myzus persicae* proved to be the most efficient vector of the virus.

In addition to papaya var. Washington Special ; the mosaic virus infected 8 more papaya varieties, bottle-gourd (*Lagenaria siceraria* Standl.), snake-gourd (*Trichosanthes anguina* L.), pumpkin (*Cucurbita maxima* Duchesne), squash (*Cucurbita pepo* L.), vegetable marrow (*C. pepo* L. var. *medullosa* Alef.), water-melon (*Citrulus vulgaris* Schrad.), *Dilpasand* (*C. fistulosus* L.), cucumber (*Cucumis sativus* L.), musk melon (*C. melo* L.), and *Luffa acutangula* Roxb. in the family Cucurbitaceae.

The virus is completely inactivated by heating for 10 minutes at 55°C. but not at 53°C., its dilution end-point lies between 10^{-4} and 10^{-3}, and it retains infectivity on ageing *in vitro* at room temperature for 26 but not for 28 hours.

The mosaic virus is of the non-persistent type and is named as the '*papaya mosaic*' virus. It has been classified as *Carica* virus-1 according to Smith [1937], and designated as *Marmor papayae* n. sp. according to Holmes [1948].

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METHOD OF STORING JUTE SEED AND EFFECT OF AGE OF SEED ON YIELD OF FIBRE

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SINCE the creation of Pakistan resulting in loss of major jute producing areas, more and more acreage in India is being brought under jute cultivation. The task of growing more jute now rests with the cultivators of West Bengal, Assam, Bihar, Orissa, and Uttar Pradesh, these areas being suitable for jute cultivation. For the last few years, there had been an acute scarcity of good jute seeds in all these areas and due to heavy demand non-viable seeds had found way into the genuine seed stocks as adulterant. This led to failure of crop in many areas. Normally good quality seed is raised in areas where there is no rainfall during October to December when jute seeds mature : rain in this period impairs the viability and helps the spread of the fungus *Macrophomina phaseoli* which is seed borne pathogen of jute. Hence, cultivators prefer seeds imported from areas of Midnapore, Muzaffarpur, Darbhanga, and Purnea where normally there is no rain in winter. It has been found that adulteration of fresh stock from these areas with non-viable seeds of old stock is a very common practice. Investigations were, therefore, conducted on factors leading to the quick deterioration of germinability of seed.

Experimental

The result of investigation [1951] showed that the moisture content of the seed at the time of storage as well as atmospheric humidity during storage, were the most important factors controlling viability of jute seeds. Seeds with minimum moisture content (7·2) remained viable for a longer time. It was also observed that in damp atmosphere the seeds deteriorated more quickly. Similar results were obtained by Barton [1941-43] working with certain vegetable seeds.

In December 1948, fresh seeds of the variety D154 (*Corchorus capsularis*) and Chinsurah Green (*C. olitorius*) were collected, dried for four full days and were then stored in glass bottles, earthen pots, gunny bags, and seed bins. Samples were treated in some cases with tolyl mercuric acetate. Table I gives the result of periodic germination tests of the stored samples.

In December 1951, D154 seeds were harvested and stored on January 7, 1952 after proper drying. The containers used were single and double gunny bags, gunnybag lined with Kraft paper and gunny bag lined with plastic cloth. The bags were kept in a damp godown on a platform made of split bamboo. Germination

TABLE I

Record of germination and disease in stored seeds

Particulars regarding condition of storage	*Corchorus capsularis* : D154						*Corchorus olitorius* : Chinsurah Green					
	Dates of observation											
	25-7-49		10-12-49		29-5-50		25-7-49		10-12-49		29-5-50	
	G.P.	D.P.	G.P.	D.P.	G.P.	D.P.	G.P.	D.P.	G.P.	D.P.	G.P.	G.P.
1. Treated, in gunny bag, in contact with floor	89·1	0·0	*	..	..	..	93·5	1·0	2·5	0·3	*	..
2. Treated, in gunny bag, on bamboo platform 10″ above the floor	90·2	0·7	*	..	..	..	93·7	0·7	*	..	*	..
3. Treated, in seed bins, in contact with floor	93·2	0·6	93·1	0·5	84·9	0·0	97·7	0·0	97·5	0·0	92·4	0·0
4. Treated, in earthen pots, in contact with floor	85·8	1·4	*	..	..	..	90·4	0·2	0·5	0·7	*	..
5. Treated, in earthen pots, exposed to sun thrice in two months	86·7	1·4,	*	..	..	..	91·4	0·5	1·6	0·5	*	..
6. Treated, in glass bottles	91·7	0·1	90·6	0·4	90·6	0·0	96·2	1·1	96·6	0·9	90·9	0·0
7. Treated, in glass bottles, exposed to sun twice in two months	90·1	0·0	92· 0	0·0	90·2	0·0	97·9	0·2	95·2	0·4	93·4	0·0
8. Untreated, in bottles	88·5	6·7	87·9	4·8	87·5	0·0	95·4	2·7	95·0	1·3	94·0	0·0
9. Untreated, in bottles, exposed to sun occasionally	88·5	6·7	87·2	4·9	87·5	0·0	96·5	3·9	96·0	1·0	95·5	0·0

* Lost viability. 'Treated' indicates treatment with tolyl mercuric acetate before storing.

G.P.—Germination percentage. D.P.—Disease percentage.

tests were carried out on the 13th February, 1954. Samples were drawn from the outer layer of six inches and from the centre. The result of the test is given in Table II.

TABLE II

Germination test of stored seeds

Nos.	Stored for months	Germination percentage of the sample drawn from	
		Inner layer	Outer layer
	(Container : Gunny bag with plastic lining)		
Bag No. D 11	25	88·85	88·82
Bag No. D 13	14	87·44	86·40
	(Container : Gunny bag with kraft paper lining)		
Bag No. 8	25	55·60	17·92
Bag No. 9	25	45·71	3·86
	(Container : single gunny bag)		
Bag No. D 1	25	24·46	0·0
Bag No. D 2	25	35·7	0·0
Bag No. D 7	25	38·67	0·0
	(Container : double gunny bag)		
Bag No. D 5	....	65·07	1·15

In all bags except those lined with plastic cloth, samples from outer layer showed comparatively lower percentage of germination than samples from inner layer. This clearly indicates that as plastic cloth was impervious to moisture laden air, the seeds remained viable, while single or double gunny bags and gunny bags lined with kraft paper could not prevent entry of moist air. The outer layer being more exposed to the action of atmospheric moisture, deterioration started from periphery towards centre : the outer layer acted as a jacket and to some extent checked the entry of moist air towards the centre.

Tables I and II, show that under usual godown conditions the seeds in containers other than those impervious to moist air, lost viability more quickly. From this point of view gunny bags lined with plastic cloth* are very suitable for storing seed. Table I shows that treated seeds could be stored for a considerable period provided they are kept in air-tight containers and preferably in a dry godown. The results show that surplus seed of the season could be profitably stored without impairing its viability.

*This is now being manufactured by some mills in Calcutta.

There is a belief, however, that old seeds produce a crop which flowers untimely. As, unlike cereals, the yield in jute depends upon a good vegetative growth, untimely flowering marks the end of the activity of the vegetative period, i.e. no further fibre is produced. Under favourable circumstances there may be a renewed vegetative growth ; in such cases during extraction much difficulty is encountered and the quality of the fibre becomes poor. In 1951, two replicated and randomized yield trials were conducted with old and fresh seeds of both *Corchorus capsularis* and *C. olitorius*. The trials were conducted in the Government Agricultural Farm, Chinsurah. No manure or fertilisers were applied in the field to encourage vegetative growth of the crop. The seed of the particular species were of the same variety and were stored in different containers for different lengths of time as stated in Table I. Germination tests were made immediately before sowing and the seed rates were adjusted accordingly. The intercultural operations were as usual. There were six replications. The results are given in Tables III and IV. Observations on the time of flowering show that there were no differences in the onset of flowering amongst the different treatments. It was also same that the differences in yield were not significant.

Table III

Comparative yield of crop raised from old and fresh seeds of C. capsularis (D154)

Plot size 8ft. × 9ft.—Harvested on 14-9-51—Sown on 28-5-51

Treatments	Germination on date of sowing	Total yield of 6 plots (gm.)	Percent on control	Maunds per acre
1948 collection, treated on 23-5-49, stored-in bottles exposed to sun occasionally.	72 per cent	8607	103·67	23·25
1948 collection, untreated. Stored in bottles exposed to sun occasionally.	55 per cent	8080	97·33	21·82
1948 collection untreated. Stored in seed bin. Stock obtained from rejections of Botany Section.	7 per cent	7500	90·34	20·26
1949 collection. Treated. Stored in seed bin	68 per cent	7788	93·81	21·04
1949 collection, untreated. Stored in tin	90 per cent	8520	102·63	23·01
1950 collection : pods and seeds were rain-soaked. Collected immediately following rains and dried in sun.	95 per cent	7927	95·48	21·41
1949 seed, treated, stored in bottles with excess of dust	85 per cent	7245	87·27	19·57
1949 seeds, untreated. Stored in bottle	80 per cent	7896	85·11	21·33
1950 collection, untreated. Usual storing. Stock from Agronomy Section (Control).	..	8302	100·00	22·43

P Large
S. E. per cent 6·6.

TABLE IV

Comparative yield of crop raised from old and fresh seeds of C. olitorius (*C. G.*)

Plot size 8ft. × 9ft.—Harvested on 14-9-51—Sown on 30-5-51

Treatments	Germination on date of sowing	Total yield of 6 plots (gm.)	Per cent on control	Maunds per acre
1948 collection, treaetd, 12-7-49. Stored in bottle occasionally exposed to sun	81 per cent	7130	91·89	19·26
1948 collection, treated and stored in bottles	46 per cent	7508	96·77	20·28
1949 collection, treated and stored in seed bin	57 per cent	7291	93·84	19·67
1949 collection, untreated. Stored in tin	98 per cent	9176	118·26	24·72
1950 collection. Pods were rain-soaked immediately before collection. Sundried and stored in tin.	81 per cent	7362	94·88	19·89
1950 collection. Untreated. Usual storing in gunny bag	84 per cent	7759	100·00	20·96

S. E. per cent 6·36
P Large

A somewhat similar yield trial was conducted in 1954 with old seeds of different varieties stored for different lengths of time with fresh seeds as control. A detailed observation has shown that the sequence of flowering was mainly according to the nature of the variety, i.e., early or late type. Sowings were done on three different dates, viz., 17-4-54, 8-5-54 and 27-5-54. The records of flowering are given in Table V. Both Fanduk (*C. capsularis*) and C. G. (*C. olitorius*) which are known early types, as usual, flowered earlier than D154 (*C. capsularis*), JR0-632 and JRJ-753 (*C. olitorius*). Slight variations from plot to plot were mostly due to unknown micro-climatic factors. Crops which were raised from old seeds did not flower earlier than those from fresh seeds.

Table VI gives the particulars of storage, stand per plot and actual yields. It will be seen that use of old seed of poor germination capacity may give a poor stand and consequently give a low yield for the plot. But yield of individual plants which constitute the crop, in average, are comparable to those raised from fresh seeds. Analysis of the data show that there had been no significant depression in yield in crops raised from old seeds, due to effects of storage alone. Similar results were obtained at Dacca in 1928.

CONCLUSION

It is to be noted that in an old sample from market, the percentage of germination is likely to be low. Thus if usual seed rate is used the stand will be poor and yield would be low. But if proper adjustment of seed rate is made prior to sowing then

TABLE V

Flowering records of different treatments

Material	Stored for months	Sowing date : 17-4-54 Recorded on : 19-8-54	8-5-54 19-8-54	27-5-54 19-8-54	8-5-54 31-8-54	27-5-54 31-8-54	27-5-54 10-9-54
		134 days	121 days	109 days	132 days	120 days	130 days
Vanduk	17	100 (Percent)	100 per cent	Bud	Early pod	100 per cent	Late pod
D154	17	100	Bud	Bud	Bud	L. bud	Late flower
D154	28	100	Bud	Bud	E. bud	L. bud	Bud
D154	28	100	Bud	*Nil*	E. flower	E. bud	E. flower
D154	28	100	Bud	*Nil*	E. flower	L. bud	E. flower
D154	28	100	Bud	Bud	E. flower	E. flower	E. flower
D154	28	100	Bud	E. bud	E. bud	E. bud	E. flower
D154	28	100	Bud	Bud	Bud	E. flower	Flower
D154	28	100	Bud	Bud	E. flower	E. bud	Flower
D154	28	100	Bud	Bud	E. flower	E. bud	Flower
D154	Fresh (5 months)	100	Bud	Bud	Bud	E. bud	Bud
JRC 212	28	100	Bud	Bud	E. flower	E. bud	Bud
C. G.	17	100	Bud	Bud	100 per cent	50 per cent	100 per cent
C. G.	28	100	Bud	Bud	100 per cent	50 per cent	100 per cent
JRO—753	17	Early bud	*Nil*	*Nil*	E. bud	*Nil*	E. bud
JRC—632	Fresh (4 months)	5 Harvested on 20-8-54	*Nil*	Bud	75 per cent Harvested 7-9-54	E. bud	Bud Harvested 14-9-54

E = Early
L = Late

TABLE VI

Particulars of storage yield and stand per plot

Material	Container	Sample	Period of storage (months)	Germination percent before	1st sowing 17-4-54			2nd sowing 8-5-54			3rd sowing 27-5-54		
					Stand	B. D. (cm.)	Yield (lb.)	Stand	B. D. (cm.)	Yield (lb.)	Stand	B. D. (cm.)	Yield (lb.)
1. Fanduk	Seed bin	Composite	17	78·1	178	2·2	4·95	259	1·9	3·99	299	1·8	2·25
2. D154	Seed bin	do.	17	94·0	150	2·1	5·38	258	1·7	4·85	388	2·0	5·48
3. D154	Plastic lined gunny (D3).	Inner layer	28	32·1	96	2·3	4·76	200	1·8	4·07	108	2·4	3·34
4. D154	Plastic lined gunny (D3).	Outer layer	28	38·7	67	2·8	3·56	81	2·6	3·56	152	1·9	3·73
5. D154	Plastic lined gunny (D11).	Inner layer	28	88·6	230	2·2	5·77	258	1·6	4·45	287	2·0	4·59
6. D154	Plastic lined gunny D11.	Outer layer	28	81·9	199	1·8	4·92	190	2·3	5·74	285	1·8	3·75
7. D154	Kraft perper lined gunny (D8).	Inner layer	28	30·2	77	2·2	2·42	123	2·2	4·13	77	2·2	2·01
8. D154	Kraft paper lined gunny (D8).	Composite	28	11·4	42	3·0	3·61	92	2·0	3·36	53	2·6	2·82
9. D154	Plastic lined gunny (D3).	do.	28	39·4	137	2·2	5·40	104	2·2	3·85	113	2·4	3·73
10. D154—													
Fresh stock	Single gunny		5	100·0	213	1·9	5·35	298	1·7	6·01	331	1·7	4·63
11. JRC 212	Seed bin		28	10·8	90	2·7	5·93	12	3·8	1·17	4	3·8	0·70
12. C. G.	Seed bin		17	81·7	250	1·5	4·52	217	1·7	4·42	112	1·4	1·85
13. C. G.	Seed bin		28	34·4	132	2·1	4·70	110	1·7	3·89	104	1·7	2·42
14. JRO—753	Seed bin		17	85·3	234	1·6	5·22	140	1·3	4·64	333	1·3	4·85
15. JRO—632													
Fresh stock	Seed bin		4	100·0	253	1·5	5·16	159	1·6	4·54	415	1·4	5·28

resulting crop would be normal. However, it is very necessary that if old stock is to be used to raise a crop, the germination test must be carried out closely preceding the sowing date ; for it has been found that once a given sample begins to deteriorate, the decline is sharp and chances of having a poor stand is obvious. In order to ensure a normal crop, while it is advisable to use fresh seeds, it is important that in an old sample the germination percentage should remain constant for two successive tests at an interval of 15 days closely preceding the sowing date.

The most important point with jute seeds is that it should be well stored in dry conditions after thorough sunning. For containers, gunny bags with plastic lining are recommended.

Summary

Jute seeds could be stored for more than 19 months without impairing its germinability, provided the moisture content is brought to minimum by thorough drying in sun and then storing them in air-tight containers. No significant variation in yield is observed between crop from old and fresh stock, provided there is no variation in stand.

Acknowledgement

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STUDIES IN THE DISEASES OF *MANGIFERA INDICA* LINN.

GIRDLE NECROSIS—A VARIATION FROM TYPICAL MANGO NECROSIS*

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[With Plate II.]

DURING the survey of mango orchards in the vicinity of Lucknow (in connection with Mango Necrosis Scheme) the author came across a type of necrosis which at a particular stage formed a characteristic girdle around the sinus region of the fruit; from this typical symptom the name 'girdle necrosis' is derived. The survey of these orchards for four consecutive seasons revealed the presence of girdle necrosis in four orchards.† The three varieties of mangoes in which it has been observed so far are *Dasehri*, *Safeda*, and *Khasli* of which the former two are more susceptible which are also the varieties most susceptible to typical necrosis [Das Gupta and Verma, 1939]. While most of the trees affected with necrosis had 1-2 per cent fruits showing girdle necrosis, in two *Dasehri* trees in Nawabali orchard the fruits with girdle necrosis were half the total number.

As in the incidence and early developmental stages the girdle necrosis showed a marked deviation from the typical necrosis, the disease was worked out in some detail as it was considered different from typical necrosis. The results are embodied in this article.

No infective organism could be isolated from the diseased fruits indicating non-microbial origin of the disease.

Symptomatology

In *Dasehri* variety the earliest symptom of girdle necrosis was first detected when the fruits were 2-2½ in. long, the largest being 4½in. The fruits at this stage are usually two months old. Typical symptoms of girdle necrosis as shown by *Dasehri* mangoes are described here. The symptoms in *Safeda* are similar but in *Khasli* they are less pronounced.

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* Contribution from the Botany Department, Lucknow University, New Series.

†1. Nawabali orchard on Fyzabad Road.
2. K. B. Asghar Husain orchard on Fyzabad Road.
3. Bahadurpur orchard on Kursi Road, and
4. Utraithia orchard on Rae Bareli Road, Lucknow.

(a) *External symptoms*

The first external symptom of the disease is the appearance of two, three or more small isolated aetiolated areas towards the distal end of the fruit in the region of sinus. Invariably associated with this aetiolation, even in the earliest stage, there is deformation of the lower region of the fruit which extends from the distal tip through the region of sinus up to lower trunk (Plate II, Figs. 1 and 2). In each of these aetiolated areas brown spots develop which later on coalesce to form a dark brown necrotic area as in typical necrosis (Plate II, Fig. 3). The necrotic areas gradually extend and coalesce to form a more or less complete girdle of shallow, depressed necrotic tissue delimiting green tip region (Plate II, Fig. 5). This is the most characteristic feature of this type of necrosis. The following regions can be distinguished in the affected fruits at this stage : green part comprising shoulder and upper trunk (a) ; the necrotic part of sinus region (b) ; a narrow aetiolated zone (c), between (a) and (b) ; and green tip region (d).

The disease may not pass through all the stages described above but can be arrested at any stage of its development. The growth of the fruits is retarded even with the earliest stage of girdle necrosis and the fruits do not ripen properly. In final stage of the disease the green portion of the tip region also becomes necrotic (Plate II, Fig. 6). The seed is seen protruding beyond the flesh with layers of collapsed necrotic tissues over it and unless the development of the disease has been followed up carefully from an earlier stage it is difficult to distinguish it from typical necrosis [Das Gupta and Verma, 1939]. In rare cases advanced stage of the disease is accompanied by ' gummosis ' from the necrotic region.

(b) *Internal symptoms* (*Histopathology*)

Histopathology was studied by means of hand and microtome sections of mangoes of different stages of necrosis. Starting from the first external symptom of aetiolation it was observed that beneath the aetiolated epidermal region in the mesocarp the cells show discolouration. The discolourd mesocarp tissue gradually disintegrates till a cavity is formed underneath each necrotic spot. It is at this stage that the aetiolation of the epidermis becomes externally visible followed by the appearance of brown spots. The cavities increase in size due to further disintegration of the tissue, coalesce and become continuous below the epidermal necrotic skin, which eventually collapses exposing the seed covered by a thin layer of necrotic tissue.

Das Gupta and Sinha [1944] discovered the presence of certain brown deposits in the vessels and cells lining the ducts of the outer mesocarp of the aetiolated fruits showing the earliest stages of typical necrosis and this was later worked out in detail by Das Gupta and Asthana [1944] with both fresh and preserved necrotic fruits. The same technique as employed by Das Gupta and Asthana was also employed for this work which was mainly of maceration of the tissues by means of weak solution of alkali. The fruits to be examined were treated with 5 to 10 per cent solution of potassium hydroxide and boiled till the parenchymatous tissue got softened. The material was then washed in running water to remove all traces of alkali. The ducts and vessels were picked up, teased and examined.

EXPLANATION OF FIGURES OF PLATE II

Fig. 1. A fruit showing early symptoms of the disease. Note the disfiguring of the lower half of the fruit with small aetiolated spots and appearance of brown dots in the aetiolated areas.

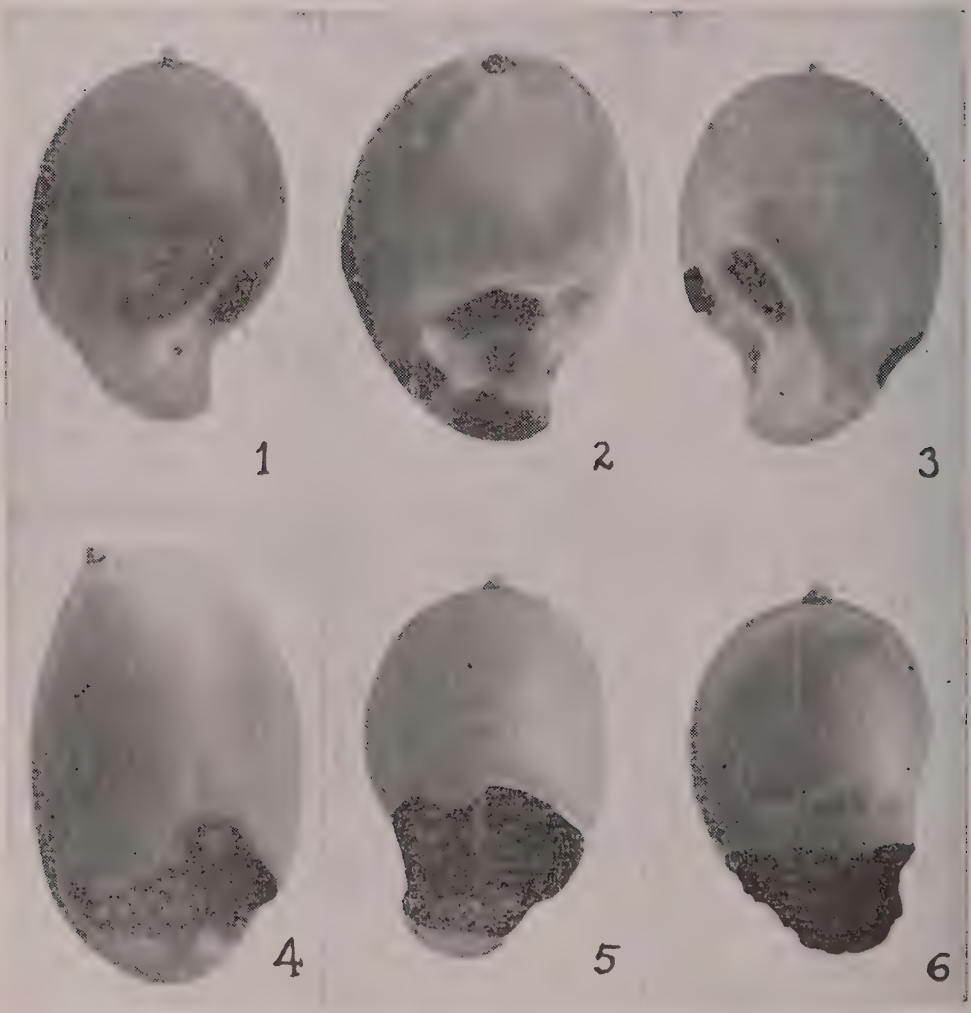
Fig. 2. Brown dots coalescing to form the necrotic area.

Fig. 3. Two such patches increasing in size to coalesce and form the girdle of necrotic tissue.

Fig. 4. Characteristic shape of girdle necrosis.

Fig. 5. Advanced stage of the disease. Very little green portion is left at the distal end.

Fig. 6. Formation of continuous necrotic area due to further advance of the disease. This stage is hardly distinguishable from that of usual necrosis.



Safeda variety of mango
For explanation of figures see back of the Plate II

The fresh diseased fruits showed copious presence of deposits in the ducts and vessels in the necrotic region and the tissue adjoining it. Further up in the trunk region they were rarer while in the shoulder region and near the stalk end the deposits were again intense. The fruits showing earliest symptom of the disease showed presence of yellow to yellowish brown deposits in the vessels at the zone of attachment of the fruit to the stalk.

A gradual transition was observed both in the nature and colour of these deposits in different regions of the fruit. The transition could also be correlated with the stage of the disease. In the advanced stage the deposits in the zone of attachment of the fruits to the stalk showed deep yellow colour, occasionally with a reddish tinge. Lower below in the non-necrotic trunk area the deposits were usually yellow coloured and viscous which gradually became more intense in the necrotic region and assumed a deep yellow to reddish yellow colour and more or less a solid consistency.

Histopathological changes of diseased fruits, after keeping them for varying lengths of time in preservatives like (1) liquid paraffin, (2) mustard oil, (3) 90 per cent alcohol, (4) 5 per cent alkali solution, (5) formalin and (6) form acetic alcohol, were also studied. The first four, viz., liquid paraffin, mustard oil, 90 per cent alcohol and alkali solution were non-reactive as the diseased fruits preserved in these fluids showed that the distribution and the intensity of the deposits remained nearly the same as in case of the fresh diseased fruits. While in the last two, i.e., formalin and form acetic alcohol, certain changes were affected in the preserved fruits as to the distribution of the deposits. There was also intensification of the colour of the deposits which became denser and distributed all along the fruit along with a general increase in the quantity of the deposits. These fluids containing formalin proved to be reactive in bringing about changes in the quantity and distribution of the deposits.

Discussion

The girdle necrosis of mango fruit described in this article differs from the typical necrosis which has been described by Das Gupta and Verma [1939] and Sen [1943] in the fact that in the former the disease has no fixed focus of incidence and may appear at any place in the sinus region of the distal end, as against the incidence of typical necrosis in the very tip of the fruit somewhat removed from the point of insertion of the style. The simultaneous formation of more than one foci of incidence in girdle necrosis is another feature which is never met with in typical necrosis. The disintegration of the necrotic tissue at the points of incidence and their subsequent coalescence producing an annular ring at the sinus region separating the non-necrotic trunk from the tip region are further characteristics of this kind of necrosis. At this stage the difference of the girdle and typical necrosis is very clear. Further advance of the disease towards the distal end gradually engulfing the tip region at the final stage of the disease makes it indistinguishable from the final stage of typical necrosis when due to the collapsing of the necrotic tissue the seed protrudes out.

The sequence of symptoms associated with the disease does not differ from typical necrosis, but the deformity of the lower half of the fruit invariably associated with girdle necrosis is a feature of great interest that again helps to distinguish it from typical necrosis. Such deformity has never been observed in the absence of the incidence of the disease and there is enough evidence to suppose that it is associated and induced by the same factor that produced necrosis.

It should be noted that typical necrosis and girdle necrosis are not exclusive of each other as they were invariably associated and occurred in the same orchards in the neighbourhood of brick kilns.

The histopathological changes associated with girdle necrosis are also similar to those found in typical necrosis as described by Das Gupta and Sinha [1944] and Das Gupta and Asthana [1944].

The absence of any infective organism in the diseased fruits, occurrence of the disease near brick kilns and the general similarity of the symptoms of the disease indicate that the girdle necrosis too is caused by the same substance that causes typical necrosis. It is not unlikely, however, that further researches might show that in the more intense form of typical necrosis the foci of incidence instead of appearing in one particular spot very near the tip appear usually in the sinus region and the subsequent differences are consequential.

Summary

A non-pathogenic necrosis of the mango fruit which differs markedly in its symptoms from typical necrosis in the earlier stages has been described in this article as ' Girdle necrosis '.

The disease has been found in orchards associated with the typical necrosis, though incidence is much rarer.

The symptoms have been described in detail and the difference from the typical mango necrosis commonly known as ' black-tip ' disease has been clearly brought out. They follow the same sequence, except that the foci of incidence may be more than one and in the sinus region. Coalescence of these at an advanced stage of the disease produces a girdle of necrotic tissue, a characteristic feature from which this name is derived.

The internal changes of the fruit associated with the different stages of the disease along with the occurrence and distribution of the deposits in ducts and vessels have been studied. In these they do not differ from the typical necrosis.

From these facts a close relationship has been derived between the typical necrosis and the type described here.

Acknowledgment

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BANANA RESEARCH IN MADRAS

(A REVIEW)

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PERENNIAL crop research in India is only of recent origin, especially after the Indian (former Imperial) Council of Agricultural Research has given an impetus by way of sponsoring schemes. The Co-ordinated Banana Research Scheme with the Central Station in Aduthurai (Madras State) was started in 1949. This country has the pride of place as one of the centres of origin of bananas and the earliest mention of this fruit is made in the Sanskrit literature. The wealth of banana varieties in this part of the world is unequalled by any other banana region. In other countries especially in Carribean Islands and Central America as a result of early initiation of research necessitated by the threatening of the industry by the Panama disease a good deal of progress has been attained and the banana industry there has reached a high degree of commercial importance. In India, planned research on the banana improvement has been initiated recently from 1949 onwards.

Systematic studies

This line of research in bananas after certain well merited regroupings is still being pursued by foreign workers. There is still a good amount of confusion on the taxonomy of banana. It is felt further research based on exhaustive descriptions of a large number of varieties will surely contribute to very precise and diagnostic characters, differentiating the original wild species which are supposed to build up the hybridity of the banana varieties in varying degrees. Cheesman[1] in his excellent thesis published in Kew Bulletins propounded that most of the cultivated banana varieties of Eumusa section have originated from the wild species *Musa balbisiana* Colla and *Musa acuminata* Colla as natural hybrids and this hypothesis has now been largely accepted by all workers. In South India systematic studies received attention in the hands of Jacob[2] and to some extent by Venkataramani[3]. The monograph by Jacob [*loc. cit.*] contains exhaustive descriptions of the different varieties, though his grouping of synonyms may not be complete. His naming of new species as *Musa sapidisiaca* Jacob comprising the cultivated varieties of South India though appreciated by certain workers in Kew, at best recognises the natural hybridity of cultivated varieties but does not indicate the correct specific status of the varieties.

To a large extent the problem of nomenclature is made more confusing due to the multifarious languages and dialects prevalent in the country. At the Central Banana Research Station, Aduthurai, after complete descriptive study of varieties, grouping of the synonyms has been attempted and tentatively it has been possible

Note.—Numbers over the names in the text refer to the References in the end of the article.

to reduce 141 varietal names to 56 distinct varieties. Studies are expected to be complete when observations are recorded under different situations and compared with their performance with the standards maintained at the Central Station. At present the varietal collection at the Central Banana Research Station covers most of the important varieties of the Union and the total number now stands at 180 and a thorough combing to build up completely the national collection of all the varieties is being programmed. The list of synonyms grouped so far is furnished in the appendix and the same is, however, not final.

Hybridisation

Breeding to evolve a wilt resistant Gros Michel banana has been in progress at the Imperial College of Tropical Agriculture, Trinidad for over two decades. The breeding work there still continues to centre round the synthesis of a male parent which could in combination with the Gros Michel variety produce an edible primary triploid having in full the commercial qualities of the latter coupled with disease resistance. Though the wilt disease has not yet assumed any serious stage in this country, the aim of the breeding programme has been to produce dwarfness or semi-tall stature of important commercial varieties, to evolve varieties resistant to Panama wilt and Bunchy top diseases and also to improve the fruit quality of certain commercial varieties. In the Coromandel coast the cyclone occurrence is not infrequent and evolving semi-tall strains with the existing popular commercial varieties, will be of a great economic advantage.

Initial studies at the Central Banana Research Station, Aduthurai proved that such a hybrid of intermediate characters is possible and an interspecific hybrid of *Monthan* x *Musa coccinea* (male) was obtained. But the hybrid could not be utilised for further breeding because of female sterility and absence of pollen. Vegetative progenies of this hybrid are being multiplied for subjecting to radio-active and chemical treatments to produce fertile mutants. There are at present progenies of the following six parental combinations under study.

(i) *Venneettin mannan* x *Musa balbisiana* (male)
(ii) *Raja vazhai* x *Musa balbisiana* clone *Ela Vazhai* (male)
(iii) *Raja vazhai* x *Musa balbisiana* (male)
(iv) *Poovan* x Wild banana from Anamalais (male)
(v) *Pey kunnan* x *Musa balbisiana* (male)
(vi) *Thote* x *Musa balbisiana* (male)

One other interesting observation noted was that varieties *Pey kunnan*, *Raja vazhai* and *Thote* were found to have a high degree of female fertility. This is the first time where systematic and extensive hybridisation has been taken up with set purpose using the commercially important varieties and locally available wild species with their high adoptive complex in the hybridisation programme. The hybrid material now available marks a substantial step in understanding the genetic improvement of the crop.

Survey and selection work

Survey of important banana areas in the Madras State has been nearly completed. For the guidance of growers, publications on the details of the cultivation of two leading commercial varieties, viz. the Cavendish [7] and Hill bananas [6] have been made. The cultural details with systematic status and commercial potentialities of another important banana variety of Malabar, *Vendran* is awaiting publication.* Other important achievements of survey work have been to spot out desirable mutants. A semi-tall mutant of the variety *Mons marie* an Australian variety and of *Nendran* have been selected and are under study. These two mutants spotted out are an improvement over the cultivated forms. Of more academic interest has been the recognition of an unrecorded banana variety called *Anil vazhai* with white and chocolate streaks on the leaves as well as a new form of *Musa banksii* Muell in the Singampatti hills [3].

Propagation studies

Studies made at the Central Banana Research Station at Aduthurai showed that sword suckers of both *Monthan* and *Poovan* varieties have flowered and fruited earlier than broad leaved suckers. Nursery investigations show that it is quite possible to use bits of rhizomes of parent plants as well as of daughter suckers as equally efficient material for propagation. It was observed that no significant differences were found between the performances of plants raised from whole rhizomes and bits of rhizomes in respect of *Poovan* and *Monthan* varieties. Further the plants raised from mother rhizomes and daughter rhizomes of these two varieties, did not show difference in performance. These results indicate the possibilities for the use of wider range of propagating material when the multiplication of rare varieties and shy suckering ones has to be tackled.

Plantation practices

Among the plantation practices the manurial requirement of the crop is a vital problem. Past trials in various research stations of this State have not been on a co-ordinated scale. In the Agricultural Research Station, Samalkota (Andhra) the manurial schedule evolved was 20 cartloads of cattle manure and 1,000 lb. of ammonium sulphate per acre. At the Central Banana Research Station, Aduthurai, results of a manurial trial conducted in wetlands, with *Poovan*, the leading dessert variety of the State, indicate that the best manurial dose per plant is given by the treatment in which $\frac{1}{4}$ lb. N is applied as cattle manure and $\frac{1}{4}$ lb.N as ammonium sulphate in two doses and the first dose three months after planting and the second five months after planting in addition to the basal dressing of 25 lb. cattle manure per plant [4]. It is significant to note that under wetland conditions with heavy clay soils of the Cauvery deltaic tract, there was no response to potash or phosphoric acid.

In bananas, other important cultural aspects are the desuckering and mattocking operations. Regarding the time of allowing a follower, when the mother plant is growing it was found that the retention of only the sucker produced after the

*Since published in the Indian Journal of Horticulture.

inflorescence is thrown out, is the best practice and until then all the suckers have to be desuckered in commercial wetland plantations. In the mattocking studies it was found that treatments cutting the pseudostem half its height or leaving it untouched soon after the harvest of the bunch significantly recorded better bunch weight in the follower than the third treatment wherein the pseudostem was completely removed. These results go to show that the followers draw as much nutrition as possible from the parent rhizome.

Since the inception of the station at Aduthurai in 1949 two cyclones have swept the area and the bananas were the worst affected. Despite the successive havocs caused by the cyclones opportunity was not lost sight of in gathering some information of both scientific and of practical utility. Among the completely unaffected varieties by the maximum wind velocities ranging from 70 to 100 miles per hour can be listed the dwarf group, viz., *Mauritius*, *Vamanakeli*, *Basarai*, *Jahaji* or *Kabulee*. Under medium tall varieties, *Rasthali* one of the choicest dessert varieties of the State, is found to resist in a greater measure high winds than other varieties. Probably the deeper root system enables the variety to withstand wind velocity. Among the tall varieties, *Monthan*, the leading culinary variety of the State has shown a fair degree of resistance so much so there was only negligible damage in the less severe cyclone of 1955 while in 1952, the damage was heavy. As regards the other commercial dessert variety *Poovan* it was noted that the pseudostems were more turgid tending to break off easily. These experiences of the cyclones have been invaluable and observations recorded during the salvage operations reveal that bunches of these plants whose pseudostems have not been severed completely in the middle or completely fallen flat with few roots snapping at the bottom can be safely carried to maturity without much deterioration and also without lowering the market value appreciably. Likewise, in the majority of cases even half mature bunches can be gradually advanced to three-fourths mature stage. The experience gathered under the shadow of two calamities strongly indicates that adjustments of planting dates especially in wetland bananas, can circumvent the contingency of the peak harvests getting caught in the usual cyclone month of November. Alignment of wind belts, providing better anchorage by firmer roothold and promoting greater strength of the pseudostem are the other important aspects of research for the future programme.

Disease

Without the mention of Panama disease, a review of the research on bananas could not be complete. Hybridisation work carried out in the Imperial College of Tropical Agriculture, Trinidad for evolving a completely resistant variety acceptable to all market standards, has not yet reached conclusive stage. Fortunately, some of our important varieties like *Poovan* and dwarf *Mauritius* are highly resistant while there are also susceptible varieties like *Rasthali*, *Monthan*, *Pacha Nadan*, etc. It has to be noted with caution that Panama disease which was unheard of a few decades ago in this country, is slowly making its appearance in some of the tracts of this country. Apart from the hybridisation work being pursued for breeding resistant varieties, rigid enforcement of quarantine measures coupled with the elimination of susceptible varieties in the cultivation to the extent possible have to be

adopted. A popular note on the disease, symptoms and preventive and remedial measures on the wilt disease has been published in the '*Mezhichelvan*'.

Hill Bananas

Among the other items which have not so far been tackled in the improvement of bananas, problems obtaining in the cultivation of hill bananas of Madurai, have not been given proper attention. The banana industry of this district is a well organised one and hill bananas are unsurpassed in its quality by any other variety and it is imperative to protect that industry now receiving a setback. Slowly hill bananas are spreading to other areas of the State, for example in Sheveroys of Salem District and to foster the expansion of the industry on right lines, a programmed research is necessary.

Marketing

Marketing of bananas is in a disorganised state. Entire production is mostly consumed within the country. Bunches of southern districts are exported to dry regions of Central districts, Rayalaseema, Mysore, etc. Wastage in transit is great in such cases because bunches are not always harvested at the optimum stage. Studies on fruit development and maturity made with the two leading varieties *Poovan* and *Monthan*, revealed that the bunches attain the best size by about the 12th to 13th week after flowering. More than the correct stage of harvesting, proper packing of bunches is an important aspect and in Queensland plastic covers have been found to be very useful in improving the quality and uniform ripening of the bunch. Preliminary studies on this aspect have been programmed for work at the Central Banana Research Station, Aduthurai.

The foregoing review will clearly reveal that only a beginning of banana improvement work have so far been tackled. When small countries and islands in Central America have built up an enviable banana industry, it is felt that a vast sub-continent like India which claims to be one of the centres of origin of this tropical fruit, should not further lag behind in going ahead with the various investigations programmed for this important fruit of the masses.

Acknowledgement

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APPENDIX

Banana Varieties—Grouping of

I—Dwarf Varieties

1. Mauritius Syn. Vamanakeli, Jahaji, Basrai, Kabulee and Pacha vazhai
2. Harichal Syn. Pedda pacha arati
3. Giant Governor

II—Medium Tall Varieties

(*a*) Black or bluish black pseudostem

4. Krishna vazhai

(*b*) Red or purple pseudostem

5. Red banana Syn. Chenkadali, Sevvazhai, Anupan and Lal kel.
6. Sanna or Chinna chenkadali

(*c*) Green or yellowish green pseudostem

Monthan Group

7. Monthan Syn. Erode Monthan, Nattu Monthan, Madhuranga Bale, Bonthan, Bainsa, Malai Monthan, Ponthan, Pachá Bontha, Sorra Monthan, Supari, Lambi, Kanchkela, Kach kol, Bontha Arati, Bankel, Manga Kaya and Bluggoe
8. Pidi Monthan
9. Nalla Bontha
10. Sambrani Monthan Syn. Ash Monthan, Bontha Ashy and Chara Ponthan
11. Thella Bontha
12. Kuri Bontha

Batheesa Group

13. Pacha Bontha Batheesa Syn. Batheesa green, Ther Vazhai and Batheesa
14. Booditha Bontha Batheesa Syn. Batheesa Ashy
15. Nalla Bontha Batheesa

Nadan Group

16. Pacha Nadan Syn. Padathi
17. Kapur
18. Kali Syn. Cheena Bale and Gali bals
19. Vannan Syn. Ladan
20. Sirumalai Syn. Mala Vazhai
21. Virupakshi Syn. Vella Vazhai

Kunnan Group

22. Kunnan
23. Vennettin Kunnan
24. Adakka Kunnan
25. Then Kunnan
26. Thattilla Kunnan Syn. Kodappanilla Kunnan, Poovilla Chendan, Poovilla Vazhali

Peyan Group

27. Peyan
28. Boothi Bale
29. Enna Banian
30. Ney Mannan Syn. Nattu Vazhai, Nanguneri Peyan, Vayal Vazhai and Chinna Monthad
31. Vennettin Mannan

Poovan Group

32. Ney Poovan Syn. Safet Velchi, Deva Bale, Ela Arisi, Sodari, Valparai
33. Poovan Syn. Dorai Vazhai, Erode Poovad, Karpura Chakkarakeli, Mysore Poovan, Ani Poovan, Lal Velchi, Chompa, Cheeni Champa, Palayamgodan, Bangalow Vazhai
34. Motta Poovan
35. Rasthali Syn. Martaman, Rasa Bale, Mutheli, Amrithapani, Hadagalli, Banares
36. Ayiranka Rasthali Syn. Poovila Vazhai

(*d*) Pseudostem green with various shades of pink and purple

37. Puttu Vazhai
38. Suganthi
39. Chakkarakeli Syn. Thella Chakkarakeli and Then Kadali
40. Rasa Kadali
41. Wathere Syn. Singampatti and Naga Bale
42. Anaikomban Syn. Kommu Arati and Attukomban

Nendran Group

43. Nendran Syn. Nana Nendran, Thiruvodan and Chenganhikodan
44. Attu Nendran Syn. Elari, Nedu Nendran and Rajeli
45. Myndoli
46. Moongil
47. Chinali Syn. Pisang Raj
48. Chingan

Others

49. Kullan Syn. Walha and Rajapuri
50. Nendra Padathi
51. Kari Vazhai Syn. Manoranjitham
52. Pey Kunnan
53. Kostha Bontha Syn. Raja Vazhai and Raja Bale
54. Gros Michel
55. High gate
56. Thiruvananthapuram

APHIS MAIDIS FITCH AS VECTOR OF SUGARCANE MOSAIC IN INDIA

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BRANDES in 1920 reported for the first time the successful transmission of sugarcane mosaic virus experimentally to sugarcane by *Aphis maidis* Fitch. Since then, this insect has been established as an important agent of dissemination of sugarcane mosaic in nature, and is now universally recognised as a vector of great practical importance in almost all the sugarcane-growing countries of the world.

The vector of sugarcane mosaic virus in India, however, has remained undetermined so far. Previous workers from this country [Chona and Rafay, 1950] attempted to transfer the disease through the agency of *A. maidis* to certain Coimbatore varieties of cane, but were not successful and hitherto the part played by *A. maidis* in transmission of sugarcane mosaic virus in India remained obscure, and it had been believed that *A. maidis*, perhaps, did not act as a vector of this disease in India. There is no report either of any other insect found to transmit sugarcane mosaic in the country, though the natural transmission of the disease is known to occur in certain localities.

The present investigation is a renewed attempt to find out the true position regarding the role of *A. maidis* in propagation of sugarcane mosaic in India.

Material and Methods

The sugarcane mosaic virus inoculum was obtained from the naturally infected cane variety *Surkha saharanpuri* (*S. officinarum*, thick, noble type), from the sugarcane mosaic culture collections maintained in the Division of Mycology and Plant Pathology, Indian Agricultural Research Institute, New Delhi. Further multiplication of the virus was effected by mechanical inoculations on *Jowar* (*Sorghum vulgare*) and sugarcane variety *Surkha saharanpuri* following the method described by Chona and Rafay [1950]. This strain of sugarcane mosaic virus was particularly selected because it induces prominent mosaic symptoms on the cane plant itself, as also on *jowar*.

Healthy colonies of *A. maidis* for transmission work were reared on healthy plants of *jowar* and barley. In addition to this, viruliferous colonies of *A. maidis* were also raised on *jowar* plants which were infected by mechanical inoculation with sugarcane mosaic virus. The plants in both the cases were covered with screened cages and were kept in separate chambers.

The aphids were transferred from plant to plant with the help of a small camel hair brush. They were first carefully removed into a clean petri dish, and then from the dish they were transferred to the test plant. The test plants with aphids were covered with lantern chimneys, which were made insect-proof by tying a piece of muslin to their open ends at the top. At the end of the specified period of exposure, the aphids were brushed off, and the plants thoroughly sprayed with nicotine sulphate solution.

The sugarcane nursery was raised in an insect-proof house. The seed-cane material was selected from the clumps which were absolutely free from the disease. Single-budded setts were cut from the canes and were planted in 6-inch earthen pots containing well-mixed compost and fine soil. The inoculations were made when the plants were 6-8 inches high. A small dose of ammonium sulphate was given to the plants which showed comparatively slow growth or pale green foliage.

Transmission tests

Aphis maidis is of world-wide distribution and is found in abundance on common graminaceous hosts, particularly several wild grasses that grow as weeds in the cane fields. This aphid continues to breed all the year round under Delhi conditions except for the months of May, June and early July, when the weather is hot and dry. It is generally found infesting crop plants like *Hordeum vulgare*, *Avena sativa*, *Sorghum vulgare* and *Zea mays*. It does not normally colonise on sugarcane in India but a light infestation was observed during 1938 by the senior author on a few plants of *Shaharanpur*, an indigenous thin reed cane variety, growing in the field at Delhi [Chona and Rafay, 1940].

For transmission tests, large number of aphids were either confined on sugarcane mosaic infected *Sorghum vulgare* plants, or were fed for a few hours on the diseased leaves of sugarcane clipped from the mosaic affected plants. After the infection-feeding, the aphids were transferred to the healthy test plants of sugarcane. Only such aphids were transferred on the test plants that were actually found feeding at the time of making transfers. Some tests were also carried out with aphids which were colonized on the mosaic infected *jowar* plants. About 20-40 aphids were transferred to each test-plant and allowed to feed for 24-48 hours.

The sugarcane varieties used for transmission tests were Co. 312, Co. 213, Co. 313, and *Surkha saharanpuri*. These varieties were selected because all of them had been found to be rather susceptible to mosaic under field conditions.

In the course of insect feeding it was observed that aphids aggregate in the inner whorl of the partially opened leaves, because of the humidity there being higher, and prefer to feed on comparatively soft young leaves. All the above mentioned varieties of cane have not been found to be agreeable to aphid feeding. In majority of the cases it was noticed that aphids tend to die off if maintained on the cane leaves for 3-4 days. At the end of the test-feeding it was observed that only 4-5 insects of the batch of 20-40 remained alive on the test plants, and in certain cases there would be none at all except in *Surkha saharanpuri*, where mortality incidence was, usually, exceedingly low. *A. maidis* has actually been found to multiply and colonise, under laboratory conditions, on *Surkha saharanpuri* plants for a limited period.

The test plants were observed daily for mosaic symptoms and it was found that it took from two to about five weeks for the first appearance of the symptoms in the various tests carried out during March-November. The results obtained are given in Table I.

TABLE I

Transmission tests with Aphis maidis *Fitch*

Period during which the test was conducted	Inoculum	Test plant	Number of plants inoculated	Number infected
March-April, 1954	*Jowar* plants infected with sugarcane mosaic	Co. 313	4	2
July-October, 1954	Do.	Co. 312	23	—
Do.	*Surkha saharanpuri* infected with mosaic	Co. 312	12	—
Sept.-November, 1954	*Jowar* plant infected with sugarcane mosaic	Co. 213	6	—
Do.	*Surkha saharanpuri* infected with mosaic	Co. 213	7	—
Do.	Do.	Co. 313	7	2
Do.	*Jowar* plants infected with sugarcane mosaic	Co. 313	11	2
Do.	Ditto	*Surkha saharan-*	30	16
Do.	*Surkha saharanpuri* infected with mosaic	Do.	17	10

It would be observed from Table I that successful infection in the case of sugarcane variety Co. 313 was about 27·2 per cent while with *Surkha saharanpuri* it was 55·3 per cent. With other cane varieties (Co. 312 and Co. 213) no case of successful transmission was observed in any of the tests.

In several preliminary tests, extending over about three years, several other mosaic affected cane varieties, e.g. H.M. 606, 607, H. 109, Punjab S. 249-50, Co. 313, Co. 631 were used for infective feeding of the vector but in no case any evidence of virus transmission was obtained using maize, *jowar* and Co. 313 as test plants.

DISCUSSION

From the results of transmission experiments carried out with different cane varieties as shown in Table I, it would be observed that *A. maidis* transferred sugarcane mosaic virus readily to cane variety *Surkha saharanpuri*, and to a lesser extent also to Co. 313. The other two Coimbatore cane varieties tested, however, did not get infection through the agency of this aphid. The reason of failure may be ascribed possibly to the coarser and harder leaf texture of these two cane varieties and *A. maidis* being unable to pierce through it. On the other hand, a high percentage of successful transmission was obtained with *Surkha saharanpuri*, the leaves of which are comparatively softer. *A. maidis* has been observed to even multiply and colonise

on it for a limited period under the glass-house conditions. Further work is, however, necessary to elucidate the inability of the vector to pick up the virus from most of the Coimbatore cane varieties.

It is concluded that *A. maidis* can act as a vector of sugarcane mosaic in India, but it transmits the disease readily only to certain cane varieties. Also that this aphid cannot readily pick up the virus from all the cane varieties.

Earlier failures of artificial transmission of sugarcane mosaic virus with *A. maidis* in India were possibly due to the absence of the cane variety suitable for infective feeding of the vector in the tests.

Summary

Sugarcane mosaic virus has, experimentally, been transmitted by *Aphis maidis* Fitch to sugarcane varieties Co. 313 and *Surkha saharanpuri*, the percentage of infection obtained being 27·2 and 55·3 per cent respectively. Successful transmission as also the ability of the vector to pick up the virus, however, depends on the cane variety.

Acknowledgment

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STABILITY OF SOME SYNTHETIC COLOURS IN ORANGE SQUASH DURING STORAGE

EFFECT OF THE ADDITION OF MANUCOL ON COLOUR AND ASCORBIC ACID RETENTION

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(with 3 Text-Figures)

FADING of colour during storage in citrus beverages, particularly in orange squash, artificially coloured with synthetic edible colouring matters, is one of the practical problems facing the food industry. The degree of fading is found to vary widely from brand to brand of commercial orange squash. A preliminary study was, therefore, made to determine whether this variation in the extent of fading is due largely to the different colouring chemicals used or the conditions under which the beverages are stored. Since Manucol (an I.C.I. product) is now being used by some squash manufacturers for keeping the pulp in fruit beverages in uniform suspension, the investigation was extended to a study of the effect, if any, of 'Manucol' on the stability of colour and also ascorbic acid in orange squash during storage. The results of this investigation are briefly presented in this article.

Experimental

In the first instance, the following four colours manufactured by Messrs. I.C.I., were tested in order to determine rapidly their comparative stability in sulphited beverages :

1. Edicol Supra Red 10 B.S.
2. Edicol Supra Orange A.G.
3. Edicol Supra Geranine 2 G.S.
4. Edicol Supra *plus* Edicol Supra Tartrazine N.S. (15 : 85)

One per cent aqueous solution of each colour was prepared and 0·5 ml. of colour solution 1 and 1·0 ml. of solutions 2, 3 and 4 were added to 2 lb. of water. One-half of each lot was sulphited with 0·07 per cent potassium metabisulphite and the other half kept as control. The test solutions were filled into pyrex test tubes, covered and sealed with paraffin wax. These were stored as follows :

(i) Exposed to direct sunlight (temp. 35-40°C) for 5 hours daily.

(ii) Kept inside the room (27-29°C) in diffused sunlight. Initial values for optical density of the test solution were determined by means of a Lumetron photo-electric colorimeter, using the 420 mμ filter. The final values were similarly determined after 3 days and the per cent loss of colour with respect to each lot was calculated from these values of optical density. The data are given in Table I.

TABLE I

Per cent colour loss in sulphited and unsulphited aqueous solutions coloured with different synthetic colours

Treatment	Per cent colour loss in coloured solution No.			
	1	2	3	4
1. Not sulphited; kept in diffused sunlight	—*Nil*—	—*Nil*—	—*Nil*—	—*Nil*—
2. Sulphited; kept in sunlight	15·5	18·8	15·8	15·1
3. Not sulphited; kept in the sun	8·3	..	7·8	5·8
4. Sulphited; kept in the sun	46·9	35·8	39·0	17·4

On the basis of the data presented in Table I, colour No. 4, was selected for further experiments with genuine and synthetic orange squash. Another colour, i.e., Edicol sunset yellow, which was available later, was also included in the detailed experiments for which the following colours were used.

(1) Edicol Supra Geranine 2 GS *plus* Edicol Tartrazine NS (Mixed in the proportions of 15 : 85).

(2) Edicol sunset yellow.

Genuine orange squash : Sathgudi orange squash containing 25 per cent fruit juice, 45 per cent total soluble solids and 1·5 per cent citric acid was prepared and preserved with 350 p.p.m. or SO_2.

The following lots were packed in colourless 12 oz. bottles and the bottles closed with crown corks.

Lot I. Control, without colour :

(*a*) as such

(*b*) containing Manucol (3 oz. per gallon of squash)

Lot II. Squash coloured with (1) @ 1 gm. per 10 lb. of squash :

(*a*) as such

(*b*) containing Manucol

Lot III. Squash coloured with (2) @ 1 gm. per 10 lb. of squash :

(*a*) as such

(*b*) containing Manucol

Note : Solutions of Manucol and of the colours were made in a part of the water required for the preparation of squash and thus the proportions of the various ingredients in the different lots of squash were kept constant)

All the above six lots were stored as follows :

(i) Bottles wrapped with black paper and placed in the dark inside a cupboard at 25°-30°C.

(ii) Bottles exposed to direct sunlight for 5 hours daily (5 days a week). The temperature in the sun varied from 35° to 40°C.

(iii) Bottles kept in diffused sunlight inside the room at 25°-30°C.

The sets were examined at periodic intervals during a total storage period of 12 months. Colour measurements were made by the method adopted by Pruthi and Lal [1950]. The optical density of the filtrate of 10 ml. squash and 10 ml. acetone was determined using the 420 mμ filter in a Lumetron Photo-electric colorimeter. Aliquots were taken from the same bottle at periodic intervals taking care to recork the bottle everytime. Ascorbic acid was determined colorimetrically by the xylene extraction method of Robinson and Stotz [1945].

Synthetic orange squash : The synthetic orange squash was prepared by mixing appropriate quantities of water, sugar, citric acid and orange *vita crush* flavour to get a squash of 45 brix and 1·5 per cent acidity. Synthetic ascorbic acid was added to the squash at the rate of 60 mg. per 100 gm. The squash was preserved with 350 p.p.m. of SO_2 in the form of potassium metabisulphite.

The following lots were packed in colourless 12 oz. bottles which were crown corked. The concentration of colour and Manucol were the same as in the case of genuine squash.

I. Coloured with colour No. 1 :

(*a*) as such

(*b*) containing Manucol

II. Coloured with colour No. 2 :

(*a*) as such

(*b*) containing Manucol

All the above four lots were stored as follows :

(i) In diffused sunlight, as in the case of *Sathgudi* squash ;

(ii) Indirect sunlight as in the case of *Sathgudi* squash ;

(iii) Inside an incubator at a temperature of 37°C.

The sets were examined at periodic intervals during a total storage period of 10 months. The same observations and determinations were made as in the case of *Sathgudi* squash, but an additional filter, i.e., 530 mμ filter, was used for the colour measurements.

Results and Discussion

The general observations on the colour and appearance of the products are given in Table II (for *Sathgudi* squash) and Table III (for synthetic squash). Changes in the optical density are shown graphically by a few typical curves in Figs. 1 and 2 for *Sathgudi* squash and Fig. 3 for synthetic *squash*.

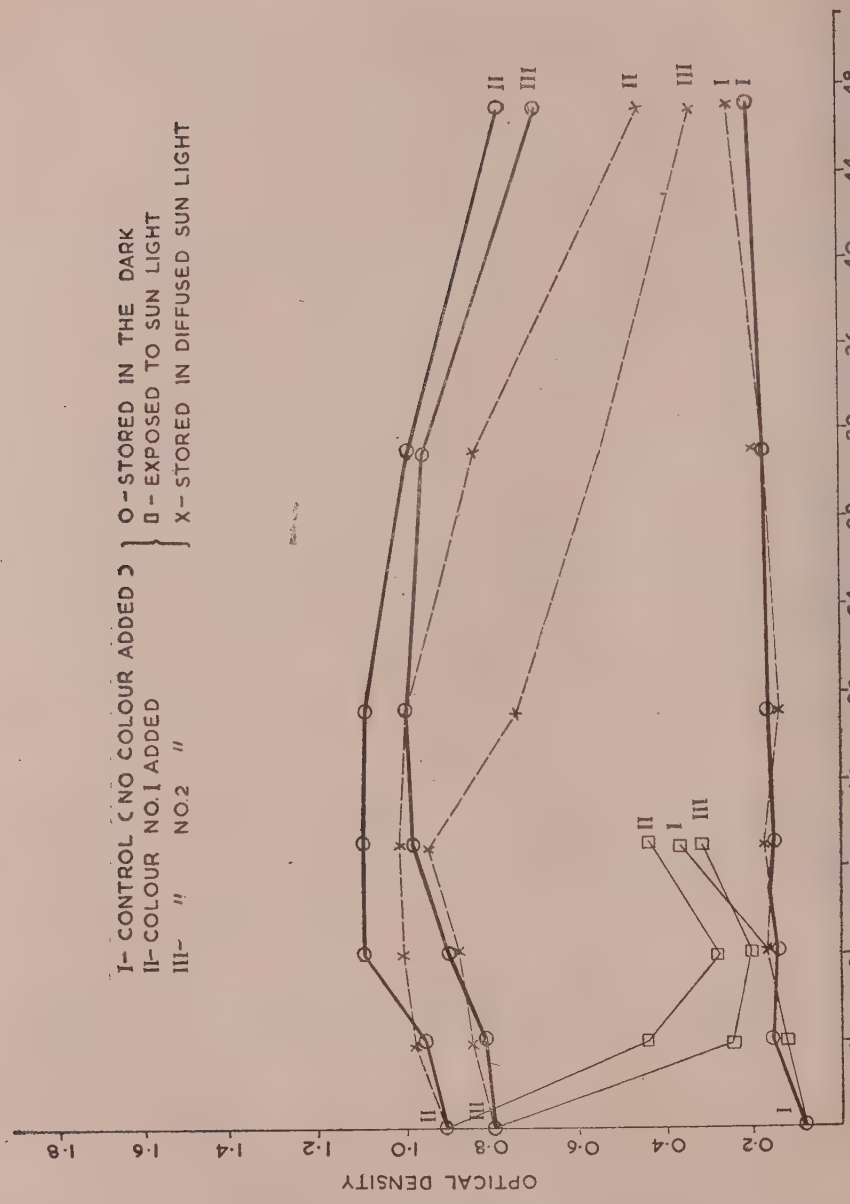

FIG. 1. Changes in optical density of artificially coloured *Suthgudi* squash (at 420 mμ) during storage.

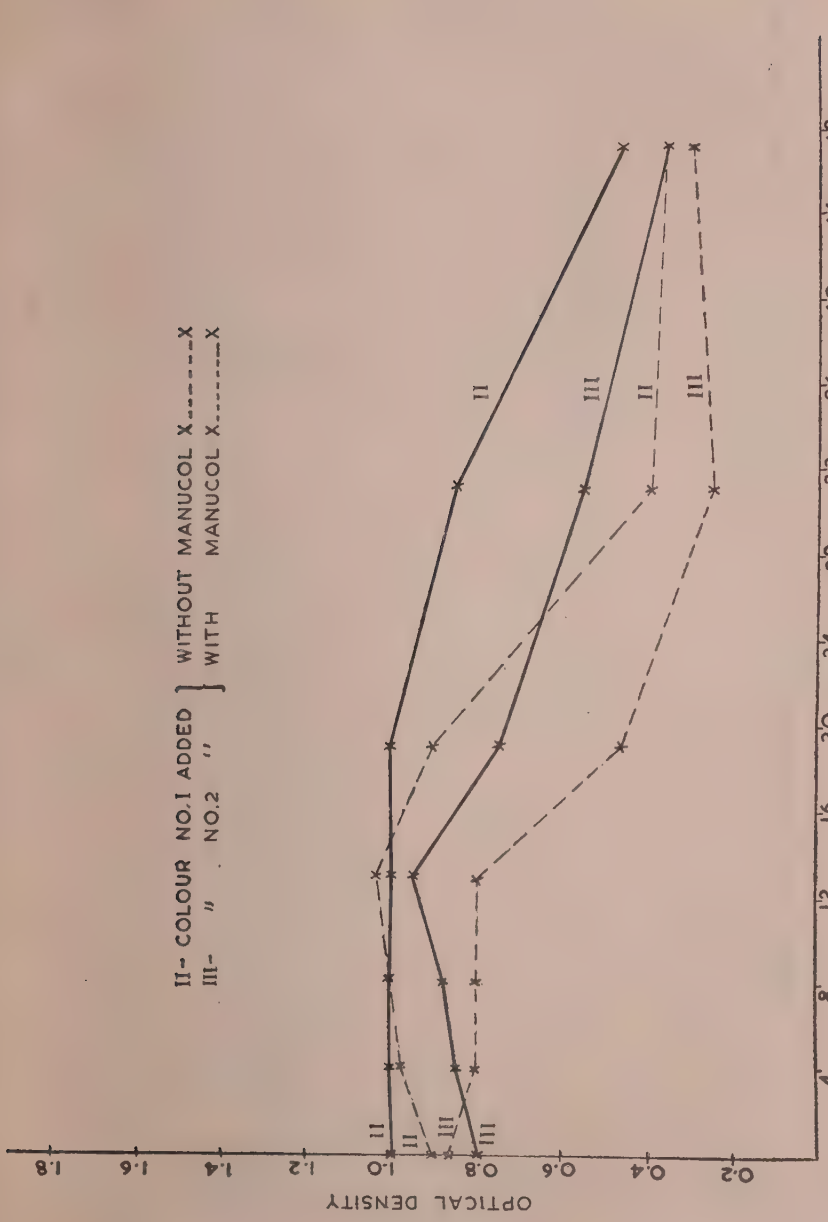

FIG. 2. Effect of addition of Manucol on colour stability of artificially coloured *Sathgudi* squash stored in diffused sun light. Changes in optical density (at 420 mμ)

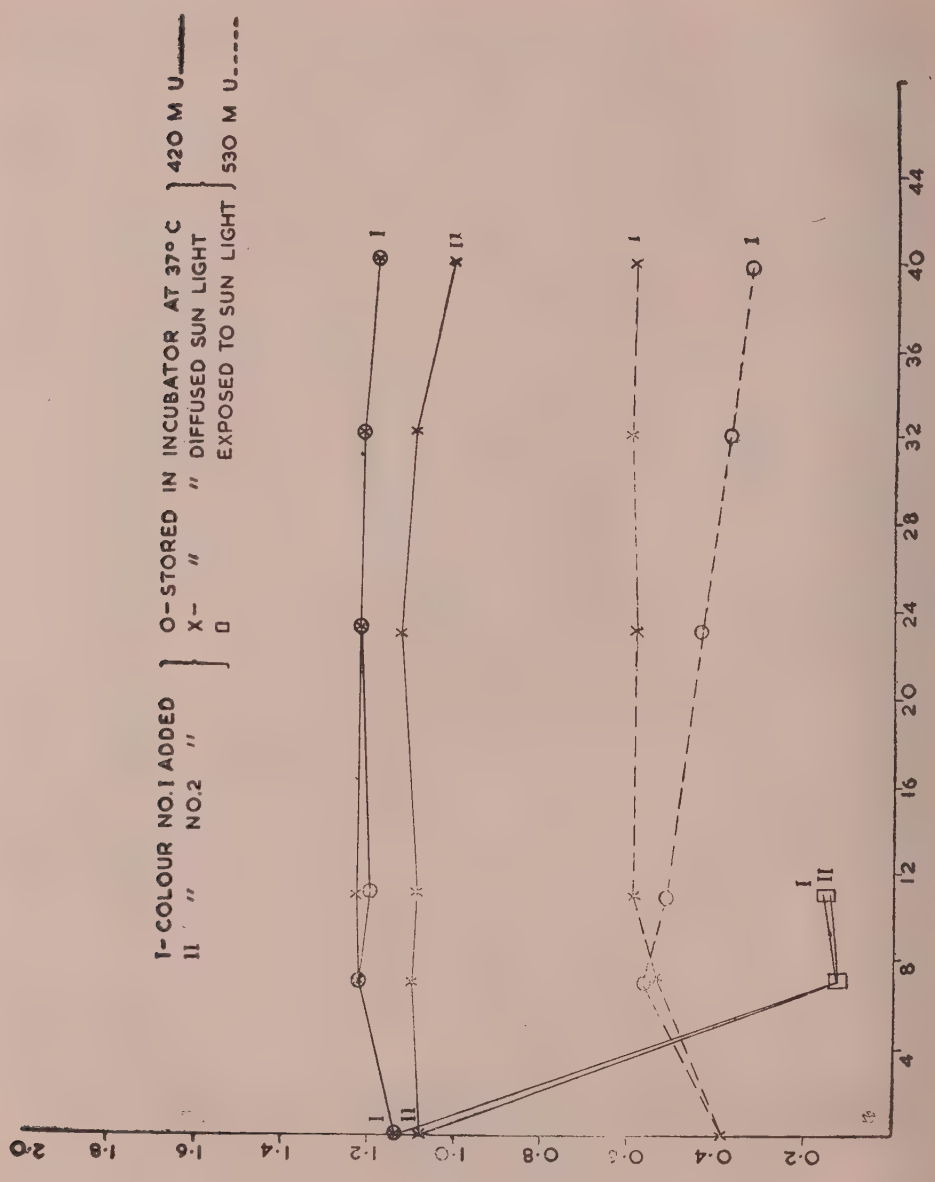

FIG. 3. Changes in optical density of synthetic orange squash (at 420 mμ) and 530 mμ during storage

TABLE II

Visual observations on appearance and suspension of pulp in Sathgudi *squash during storage*

Lot No.	Storage period weeks					
	4	8	13	19	31	47
Ia (i) (Dark)	Lumps of very light greenish yellow suspension—not uniform	Very light yellowish brown; clarified; partly floating suspension	Light brownish yellow; clarified	Light brownish yellow	Light yellowish brown	.....
(ii) (Sun)	Water-white, clarified; sediment separated completely; settled at bottom	Dull muddy colour; clarified; pulp looks precipitated	Dirty brown clarified	.....	.....	.....
(iii) (Room)	Colour lighter than in I(*a*) (i) and less cloudy Tendency to clarify	.....	Light brownish yellow	Light brownish yellow	Light brownish yellow	Light yellowish brown
Ib (i)	Colour as in *I(a)* (i); much better suspension	Colour as in I(*a*) (i); good suspension; better appearance	Light brownish yellow; fairly good suspension	Do.	Do.	.....
(ii)	Water-white; only partially clarified; suspension uniform	Colour as in I(*a*) (ii); good suspension	Dirty brown; fair suspension	.....	.....	.....
(iii)	Colour as in I (*a*)(iii); cloudy; suspension uniform	——	Light yellow; good suspension	Light brownish	Light brownish yellow	Light yellowish brown
IIa (i)	Good colour; cloudy; good suspension	Good orange-red rather deep colour; clarified; lumps in suspension	Strong orange-red colour: clarified	Orange-red	Orange-red	.....
(ii)	Light orange colour (faded); only slightly cloudy; clarified to a large extent	Colour brownish red; dull appearance; clarified like I(*a*)(i)	Dirty deep brown; clarified	.....	.....	.....
(iii)	Good colour; cloudy; coarse particles in suspension	.....	Strong orange-red colour; clarified	Orange-red	Orange-red; (Lighter than II *a*(i). Normal appearance	Orange colour; dull look
II b (i)	Good colour; suspension better than in II(*a*)(i)	Colour as in II(*a*) (i) but better appearance; good suspension	Strong orange-red colour; fairly good suspension	Orange-red	Orange-red	.....

TABLE II—*contd.*

Visual observations on appearance and suspension of pulp in Sathgudi *squash during storage*

Lot No.	Storage Period weeks					
	4	8	13	19	31	47
II (*b*) (ii)	Light orange colour lighter than in II (*a*)(ii), but more cloudy; good suspension	Colour as in II(*a*) (ii); dull appearance	Dirty brown; fairly good suspension	.....	.....	.....
(iii)	Good colour; uniformly cloudy; good suspension	.....	Strong orange-red colour; fairly good suspension	Orange-red	Orange-red (lighter); normal appearance	Orange colour looks dull
III (*a*) (i)	Good colour, lighter than II (*a*)(i) coarse suspension; clarifying	Strong orange colour; good appearance; clarified; mostly settled	Good orange colour; clarified	Good orange colour	Good orange colour	.....
(ii)	Very light yellowish colour (faded); clarified	Faint orange yellow; not attractive; clarified like I (*a*)(ii)	Dirty brown; clarified	.....	.....	.....
(iii)	Good colour; coarse suspension; clarifying	.....	Good orange colour	Good orange colour	Good orange colour (rather light) fair appearance	Light orange; rather dull
III (*b*) (i)	Good colour; uniform suspension	Colour as in III(*a*) (i); good suspension and better appearance	Good orange colour; fairly good suspension	.....	Dull orange colour	.....
(ii)	Very light yellowish colour (faded)	Colour as in III (*a*) (ii); dull appearance; good suspension	Dirty brown; fair suspension	.....	.....	.....
(iii)	Good colour; uniform suspension	.....	Good orange colour; fairly good suspension	.....	Light orange colour (not good appearance)	.....

TABLE III

Visual observations on the colour of synthetic squash during storage

Lot No.		Storage period (weeks)				
		7	11	23	32	40
1(a) (i)	Stored in diffused light (25-30°C)	Good colour	Good colour	Good orange-red	No fading perceptible	Good orange red shade
(ii)	Stored in direct sun light (35-42°C)	Complete fading	Faded	.....	.....	.....
(iii)	Stored in an incubator at 37°C	Good colour	Good colour	Strong orange red deeper than above	Darkening; some black precipitate at bottom	Strong tea decoction colour; black precipitate
1(b) (i)		Good colour	Good colour	Good orange red	Fading perceptible	Good orange red shade
(ii)		Complete fading	Faded	.....	.....	.....
(iii)		Good colour	Good colour	Strong orange red deeper than above	Colour darkening; No precipitate	Tea decoction colour; No precipitate
II(a) (i)		Good colour	Good colour	Good orange red	No fading perceptible	Good orange red shade
(ii)		Complete fading	Faded	.....	.....	.....
II(b) (i)		Good colour	Good colour	Good orange red	No fading perceptible	Good orange red shade
(ii)		Complete fading	Faded	.....	.....	.....

It will be seen from these data that,

(*a*) Sunlight is highly detrimental to the stability of the organic colouring compounds used in the study for colouring orange squash, genuine as well as synthetic.

(*b*) The colours are comparatively stable in the lots stored in the dark.

(*c*) In diffused sunlight at room temperature, i.e., under the normal conditions of storage, the colours in the *Sathgudi* squash are stable for a period of about 5 months and then begin to fade progressively.

(*d*) In the case of synthetic squash there is no visible fading when stored in diffused sunlight or at 37°C in the dark for a period of 10 months. The optical density determined at 530 mμ is, however, relatively low in the case of the incubated synthetic squash as compared with that of the same squash stored in diffused sunlight, after a period of about 2½ months. Other data too show the same trend. This gap between the optical densities gradually increases with storage. It is possible that any slight fading of the added colour that might have occurred in the incubated lots, could not be detected visually or colorimetrically at 420 mμ wave-length because of the development of some browning discolouration at high temperature, which counteracted the effect of fading.

(*e*) In the case of both *Sathgudi* and synthetic squashes, the fading of the colours is complete after about 2 months when stored in the direct sunlight, after which there is again a tendency towards darkening. This indicates the possibility of browning discolouration taking place in direct sunlight where the temperature is high.

(*f*) The control lot of *Sathgudi* squash (colour added) shows slight darkening from the 5th month onwards.

(*g*) The degree of fading, whenever it has occurred, is about the same in the case of both the colours that have been used in these experiments.

(*h*) Manucol does not have any stabilizing effect on colour. On the contrary, it seems to accelerate fading to some extent after a storage period of about 3-4 months, in the case of *Sathgudi* squash. Other data, not presented here, show a similar behaviour of Manucol under other storage conditions also. In the case of synthetic squash, however, Manucol had no effect whatever on the colour changes.

From data regarding changes in the ascorbic acid content of the two types of beverages prepared with or without the addition of Manucol and stored under different conditions (Tables IV for *Sathgudi* squash and Table V for synthetic squash), it will be seen that the differences in the values are not sufficiently marked and consistent to substantiate any stabilizing effect of Manucol on ascorbic acid. Manucol, however, has no adverse effect on the stability of the vitamin.

Summary

A study has been made of the stability of four added food colours in genuine as well as synthetic orange squash under three different conditions of storage, namely in the dark or diffused light, at room temperature and in open sunshine. The effect

TABLE IV

Changes in the ascorbic acid content of Sathgudi *squash ; effect of manucol (ascorbic acid expressed in mg./100 gm.)*

Lot No. and Storage	Storage period (Weeks)			
	Initial	4	8	13
I (*a*)	16·7			
(ii) Exposed to sun	..	7·9	4·8	0·3
(iii) Stored at room temperature	..	13·6	7·5	1·4
I (*b*)	15·8			
(ii) Exposed to sun	..	10·4	6·1	1·5
(iii) Stored at room temperature	..	12·8	6·6	2·2
II (*a*)	17·5			
(ii) Exposed to sun	..	5·8	1·5	0·8
(iii) Stored at room temperature	..	14·4	7·0	2·0
II (*b*)	16·5			
(ii) Exposed to sun	..	8·3	3·7	0·5
(iii) Stored at room temperature	..	14·7	8·1	2·6

TABLE V

Changes in the ascorbic acid content of synthetic orange squash ; effect of manucol (ascorbic acid expressed in mg./100 gm.)

Lot No.	Storage period (weeks)			
	Initial	7	11	23
I (*a*)				
(i) Stored in diffused sunlight (25-30°C)	57·7	44·4	37·6	1·8
(ii) Stored in direct sunlight (35-42°C)	57·7	34·4	27·9	Trace
(iii) Stored in incubator at 37°C	57·7	41·9	30·4	Trace
I (*b*)				
(i) Diffused sunlight	58·5	43·1	36·4	2·3
(ii) Direct sunlight	58·5	37·7	24·5	Trace
(iii) Incubator	58·5	44·1	34·4	Trace
II (*a*)				
(i) Diffused sunlight	56·7	40·0	30·0	1·1
(ii) Direct sunlight	56·7	35·8	25·4	Trace
II (*b*)				
(i) Diffused sunlight	56·5	44·9	39·4	1·4
(ii) Direct sunlight	56·5	36·5	30·0	Trace

of Manucol on this stability and also on the stability of natural as well as added ascorbic acid in these two types of squashes has also been investigated. Sunlight is highly detrimental to the stability of the added colour. In diffused light at ordinary temperatures, the colours are stable for about 5 months. In the case of *Sathgudi* orange squash, the addition of Manucol appears to accelerate fading of colour to some extent during storage, but has no effect in the case of the synthetic squash. Manucol has neither a stabilising nor any adverse effect on vitamin C in the squashes.

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PHYSICO-CHEMICAL PROPERTIES OF SUGAR CANE SAP AS AFFECTED BY SHOOT DEVELOPMENT AND PLANT PARTS

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(With 1 Text-Figure)

VARIOUS physico-chemical properties of sugarcane sap have been noted to vary with the conditions of nutrition and the parts of the plants sampled for sap extraction [Lal and Tandon, 1955 ; 1954a ; b]. Earlier work of Lal and Mehrotra [1953] showed that Co. 205, Co. 285 and Co. 395 appeared similar in their physiological characteristics of bound and free water to the behaviour of drought resistant Rheora. Paunda, Co. 312 and Co. 290 were more akin to drought susceptible POJ. 2878 in so far as bound and face water content were concerned. The extent to which different varieties of sugarcane representing drought resistant, drought susceptible and standard canes, differed in the physico-chemical properties of the sap has been further discussed in these pages.

Methods and Material

Varieties CoS. 109, Co. 245, Co. 453, POJ. 2878 and Co. 312 were sown in February, 1950, on the College Farm under normal conditions of cultivation and nutrition in unreplicated plots. At maturity (December, 1950) clumps belonging to each variety were sampled. All the tillers in these clumps were divided in accordance with their height and stage of maturity into (a) pre-monsoon shoots, more than 6 months old ; (b) post-monsoon shoots, less than four months old ; and (c) monsoon shoots four to six months old. Shoots belonging to each of these stages mentioned above were cut into three equal parts, viz. top, middle and bottom and used for extraction of sap. Although a rigid comparison of top, middle and bottom canes was not possible in post-monsoon, monsoon and pre-monsoon shoots, in view of their varying ages, still the nature of variation in each individual shoot from top to bottom was studied to provide adequate information regarding the manner in which various pysico-chemical properties changed from apical region to basal internodes. The variations thus recorded in the three shoots were discussed in relation to the fundamental processes of the plant during the three critical periods of growth.

The study in short, included the analysis of the effect of five varieties, three plant parts and three stages of shoot development on the various physico-chemical properties of the sap. Density, surface tension and viscosity [Seifriz, 1936], and osmotic pressure and solute concentration [Lal and Mehrotra, 1953 ; Schopmeyer, 1939] were estimated in the extracted sap. The contents of bound and free water in the cane stem were also determined in accordance with the method of Meyer [1932] and expressed as the percentage of total moisture in the stem.

Experimental Results

Physico-chemical properties of sap

Statistical analysis of the data showed the outstanding effects of varieties on all the sap characteristics excepting bound water. Thus density, surface tension, viscosity, osmotic pressure and solute concentration varied significantly with varieties. In top, middle and bottom canes marked variations in density, surface tension viscosity and osmotic pressure were noted. Other characters such as solute concentration and bound water did not vary significantly. With the stage of shoot development, surface tension and osmotic pressure varied markedly, while other characters did not vary significantly. Surface tension of the sap was also influenced by the interaction between varieties and plant parts, and between varieties and stage of shoot development (Table I).

Table I

Physico-chemical properties of sap in relation to different varieties, stage of growth and component parts of sugarcane

Analysis of variance

Sap Temp. 21°C 1951-52 Age 215 days

Due to	D.F.	Mean sum of squares × 1,000			
		Density	Surface tension	Viscosity	Osmotic pressure
Varieties (V)	4	0·132*	25·533*	33·645*	11406·620*
Plant parts (P)	2	1·901*	3·111*	136·910*	46637·895*
Stages (S)	2	0·074	3·859*	13·259	2775·862*
V×P	8	0·037	3·481*	6·949	544·624
V×S	8	0·045	3·903*	3·203	728·990
P×S	4	0·202	0·073	6·728	156·179
Error	16	0·029	0·806	5·261	409·804
Total	44				

* Significant at 5 per cent

TABLE I—*contd.*

Physico-chemical properties of sap in relation to different varieties, stage of growth and component parts of sugarcane

Due to	D.F.	Solute concentration	Bound water
Varieties (V)	4	678·764*	96159·400
Plant parts (P)	2	75·853	31317·250
Stages (S)	2	3·379	9799·000
V×P	8	55·211	20353·400
V×S	8	103·523	26795·212
P×S	4	45·711	15330·500
Error	16	43·683	35997·012
Total	44		

* Significant at 5 per cent

Density

Density of the sap was significantly higher in Co. 312 in comparison to other varieties and reached a higher level in bottom internodes. The difference in density of sap from top and bottom internodes was statistically significant. It was further evident that the pre-monsoon tillers tended to show relatively higher density of sap than either the monsoon or post-monsoon shoots (Table II, Fig. I).

Surface tension

Surface tension of sap of the tillers in different varieties varied from a low value of 0·793 in CoS. 109 to a high value of 0·921 in Co. 453 and 0·914 in POJ. 2878; varieties Co. 245 and Co. 312 showed no significant difference in surface tension. The middle internodes, at an average, showed significantly lower surface tension than

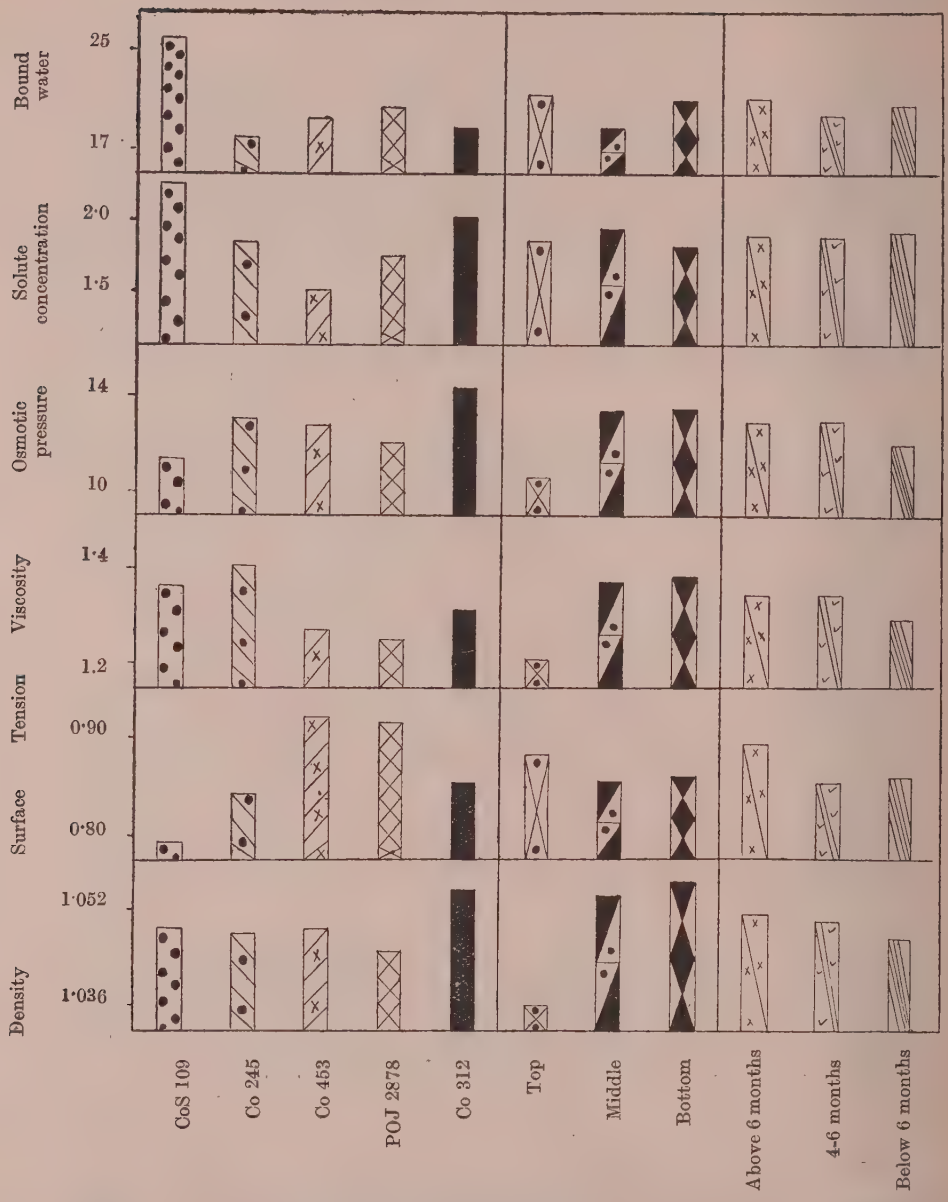

Fig. 1. Effect of varietes, plant parts and stage of shoot development on physico-chemical properties of sugarcane expand tissue fluids

the top internodes, but failed to indicate any significant variation from the bottom internodes. It was also evident that shoots of pre-monsoon origin were higher in surface tension than shoots of both monsoon and post-monsoon origin (Table II, Fig. I).

TABLE II

Effect of varieties, plant parts and stages of growth on physico-chemical of sugarcane sap

Varieties	V×P interaction			V×S interaction			Mean of 9
	Top	Middle	Bottom	Pre-monsoon	Monsoon	Post-monsoon	
A. *Density of sap*							
CoS 109	1·033	1·060	1·053	1·055	1·050	1·040	1·049
Co 245	1·036	1·053	1·057	1·046	1·048	1·051	1·048
Co 453	1·034	1·054	1·060	1·049	1·052	1·047	1·049
POJ 2878	1·034	1·046	1·053	1·047	1·044	1·042	1·045
Co 312	1·045	1·059	1·062	1·056	1·056	1·053	1·055
Mean of 15	1·036	1·054	1·057	1·051	1·050	1·047	
C.D. at 5 per cent for means of 3=0·0093 ; for 9=0·0054 ; for 15=0·0041							
B. *Surface tension*							
CoS 109	0·811	0·780	0·788	0·829	0·775	0·775	0·793
Co 245	0·795	0·847	0·887	0·842	0·814	0·873	0·843
Co 453	0·943	0·906	0·915	0·889	0·954	0·921	0·921
POJ 2878	0·962	0·888	0·894	0·941	0·888	0·914	0·914
Co 312	0·895	0·843	0·801	0·916	0·835	0·814	0·855
Mean of 15	0·881	0·853	0·862	0·884	0·853	0·859	
C. D. at 5 per cent for means of 3=0·0484 ; for 9=0·0279 ; for 15=0·0216							

TABLE II—*contd.*

Effect of varieties, plant parts and stages of growth on physico-chemical properties of sugarcane sap

Varieties	V×P interaction			V×S interaction			Mean of 9
	Top	Middle	Bottom	Pre-monsoon	Monsoon	Post-monsoon	
C. *Viscosity of sap*							
CoS 109	1·273	1·469	1·363	1·382	1·385	1·339	1·369
Co 245	1·235	1·466	1·500	1·391	1·477	1·334	1·400
Co 453	1·153	1·299	1·380	1·301	1·235	1·295	1·277
POJ 2878	1·165	1·306	1·292	1·302	1·258	1·203	1·254
Co 312	1·238	1·324	1·328	1·336	1·335	1·273	1·314
Mean of 15	1·213	1·373	1·383	1·342	1·338	1·289	

C. D. at 5 per cent for means of 3=0·1263 ; for 9=0·0794 ; for 15=0·0565

D. *Osmotic pressure*							
CoS 109	9·19	12·23	12·37	11·91	11·93	9·95	11·26
Co 245	10·90	13·82	14·24	13·10	12·88	12·97	12·99
Co 453	9·96	13·74	14·35	12·87	13·31	11·88	12·68
POJ 2878	10·37	12·25	13·08	11·98	12·02	11·69	11·90
Co 312	12·57	14·73	15·37	14·33	14·25	14·09	14·20
Mean of 15	10·60	13·35	13·88	12·84	12·88	12·12	

C. D. at 5 per cent for means of 3=1·1076 ; for 9=0·6395 ; for 15=0·4953

TABLE II—*concld.*

Effect of varieties plant parts and stages of growth on physico-chemical properties of sugarcane sap

Varieties	V×P interaction			V×S interaction			Mean of 9
	Top	Middle	Bottom	Pre-monsoon	Monsoon	Post-monsoon	
E. *Solute concentration*							
CoS 109	2·091	2·436	2·255	1·961	2·455	2·366	2·261
Co 245	1·804	1·966	1·865	1·814	1·843	1·978	1·878
Co 453	1·403	1·740	1·446	1·532	1·602	1·471	1·535
POJ 2878	1·932	1·746	1·646	2·024	1·656	1·644	1·775
Co 312	2·158	2·008	1·981	2·076	1·927	2·120	2·049
Mean of 15	1·878	1·979	1·842	1·886	1·897	1·916	

C.D. at 5 per cent for means of 3=0·3614 ; for 9=0·2088 ; for 15=0·1618

F. *Bound water content of tissues*

CoS 109	29·48	21·61	27·06	26·96	24·96	26·23	26·05
Co 245	20·19	13·14	19·98	21·60	15·81	15·90	17·77
Co 453	17·44	19·65	20·99	15·22	20·25	22·26	19·36
POJ 2878	19·73	21·38	20·21	22·62	17·11	21·44	20·40
Co 312	20·02	18·23	17·25	19·80	20·01	16·36	18·72
Mean of 15	21·37	18·80	21·10	21·24	19·63	20·44	

C. D. at 5 per cent for means of 3=8·999 ; for 9=5·196 ; for 15=4·024

Viscosity

Viscosity of the sap was higher in Co. 245 as compared to Co. 453, POJ. 2878 and Co. 312. At an average the bottom internodes were significantly higher in viscosity as compared to top internodes but indicated no significant difference from the middle internodes. Differences due to stages of shoot development were insignificant (Table II, Fig. I).

Osmotic pressure

Osmotic pressure of the sap was highest in Co. 312 and relatively low in CoS. 109 and POJ. 2878. Varieties Co. 245 and Co. 453 were intermediate. In all the varieties, the bottom internodes were significantly higher in osmotic pressure than the top internodes. The youngest shoots of the post-monsoon origin were poorer in osmotic pressure than either the pre-monsoon or the monsoon shoots which between them showed no significant difference in osmotic pressure (Table II, Fig. I).

Solute concentration

Concentration of total solute was highest in CoS. 109 and poorest in Co. 453. The middle internodes, at an average, showed higher solute concentration than either the top or the bottom internodes but the differences were not significant. This was particularly noted in CoS. 109, Co. 245 and Co. 453. In other two varieties (POJ. 2878 and Co. 312) the solute concentration showed a downward trend from the top to bottom regions of the shoot. Pre-monsoon, monsoon and post-monsoon shoots behaved more or less identically in respect of solute concentration of the sap (Table II, Fig. I).

Bound water

The content of bound water expressed as percentage of total moisture in stem was highest in CoS. 109 and poorest in Co. 245. Other varieties did not differ significantly in their bound water content. The stage of shoot development or the cane parts also indicated no significant difference in this direction (Table II, Fig. I).

Discussion

Varietal characteristics

Different varieties of sugarcane showed marked fluctuations in the physico-chemical properties of their sap. They could be classified on the basis of the various properties into two or three groups as indicated below :

Characters	High	Medium	Low	C. D. at 5 per cent
Density	*Above 1·050* : Co. 312	*1·050 to 1·045* : CoS. 109, Co. 453, Co. 245 and POJ. 2878	×	0·005
Surface tension	*Above 0·900* : Co. 453 and POJ. 2878	*0·900 to 0·800* : Co. 312 and Co. 245	*Below 0·800* : CoS. 109	0·028
Viscosity	*Above 1·330* : Co. 245 and CoS. 109	*1·330 to 1·300* : Co. 312	*Below 1·300* : Co. 453 and POJ. 2878	0·079
Osmotic pressure (Atmos.)	*Above 13·00* : Co. 312	*13·00 to 12·00* : Co. 245 and Co. 453	*Below 12·00* : POJ. 2878 and CoS. 109	0·640
Solute concentration (Mol. of solute/kg. of plant dry matter)	*Above 2·000* CoS. 109 and Co. 312	*2·000 to 1·170* Co. 245 and POJ. 2878	*Below 1·170* Co. 453	0·209
Bound, water (as per cent of total moisture)	*Above 25·00* : CoS. 109	×	*Below 25·00* : POJ. 2878, Co. 453, Co. 312 and Co. 245	5·196

Thus out of the six sap characteristics Co. 312 and CoS. 109 showed high values in three characters, Co. 453, Co. 245 and POJ. 2878 did not show consistent effects in raising these characters. POJ. 2878 and Co. 453, on the other hand, exhibited poor values in three physico-chemical properties, while Co. 312 and Co. 245 were poorest in one character each. The bound water content, density, surface tension and viscosity did not differ markedly in Co. 453 and POJ. 2878. Earlier work of Lal and Mehrotra [1953] showed that in general, Co. 285 and Co. 395 appeared in their physiological characteristics of bound and free water, similar in behaviour to that of resistant Rheora. On the other hand, Co. 312, Paunda and Co. 290 appeared more akin to POJ. 2878. To the former resistant group might also be added another variety CoS. 109.

Characteristics of pre-monsoon, monsoon and post-monsoon shoots

Data recorded in these pages also showed that osmotic pressure and other physico-chemical properties of sap differed in some cases with the stage of shoot development. Thus density, surface tension, viscosity and bound water were high in shoots of pre-monsoon origin. The summer stand was poorest in solute concentration (Table II). The shoots of monsoon origin were high in osmotic pressure but

were poor in surface tension and bound water. On the other hand, the post-monsoon shoots showed the highest concentration of solutes and were poorest in density, viscosity and osmotic pressure. What actually caused the increase in density, surface tension, viscosity and bound water content of the summer stand could not be specifically indicated. Several factors, e.g., the age and developmental stages of tissues, the climate and edaphic conditions appeared to be responsible for such variations. The data in the present section also confirm the fact recorded earlier that greater the age, the larger is the content of bound water in the plant [Lal and Mehrotra, 1953].

Characteristics of top, middle and bottom canes

The average life cycle response indicated that top portion of the cane shoots usually showed higher surface tension and bound water content. These appeared related to (i) the desiccating effects of the environment, which resulted in high transpiration and (ii) active accumulation of the minerals and hydrophilic colloids during upgrade metabolism in this region. Further the downward movement of the products of upgrade metabolism towards the bottom canes went a long way in lowering the viscosity, osmotic pressure and density of the top canes. Considerable transpiration losses also reduced the free water content in this region. It was equally significant to note that the middle internodes were rich in solute concentration but were poor in surface tension and bound water ; the latter indicated poor content of hydrophilic colloids in these regions. The bottom canes, on the other hand, were the richest in viscosity and density but were poorest in solute concentration. This being the region of storage, all soluble and insoluble material accumulated in largest amount causing a marked increase in density, viscosity and osmotic pressure of the sap. No tendency of equalization in the intensity or concentration of various properties was noted in different internodes of the mature shoots unlike that typically noted for sucrose which tended to attain similar concentration in top, middle and bottom internodes at maturity.

Summary

In this article the physico-chemical properties of top, middle and bottom canes from varieties CoS. 109, Co. 245, Co. 453, POJ. 2878 and Co. 312 were determined at maturity and discussed in relation to age and maturity of shoots. Varieties in general showed a significant effect on density, surface tension, viscosity, osmotic pressure and solute concentration. Varieties CoS. 109 and Co. 312 showed high values in nearly fifty per cent of these properties and appeared better than the other varieties. Poorest in respect of physico-chemical properties were varieties Co. 453 and POJ. 2878. No difference in bound water content of latter two varieties was noted.

Density, surface tension, viscosity and bound water were high in shoots of pre-monsoon origin. These shoots were, however, poor in solute concentration. Youngest post-monsoon shoots evinced high solute concentration but were poorest

in density, viscosity and osmotic pressure of the sap. Irrespective of these varietal characteristics, the greater the age of the shoots, the higher was the bound water content.

The average life cycle response indicated that top canes were usually higher in surface tension and bound water content but were poor in density, viscosity, osmotic pressure. The middle canes on the contrary, were richer in solute concentration but poor in surface tension and bound water. Bottom canes were high in osmotic pressure, density and viscosity but were low in solute concentration.

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